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Distinguishing Natural From Humanly Flaked Stone at Problematic Sites

by

© Douglas Wayne Schnurrenberger

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF ARTS

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Alan Lyle Bryan

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Date June 3, 1982

Abstract

The goal of this document is to evaluate the potential for evaluating the status of collections of questionable stone clasts in redeposited contexts. To this end, the problem of natural versus human modifications of stone clasts is reviewed in terms of its historical and current context. Previous approaches to this problem are reviewed and found to be unsatisfactory in terms of providing sound empirical arguments with which to evaluate questionable assemblages. To resolve this problem, a general research design is outlined which focuses attention on the contextual parameters of questonable stone clasts redeposited by a variety of natural geomorphic agencies. This research design is then applied to three concrete cases (the Timlin site, the Caribou Island site, and the ESP site) where stone clasts of questionable origin have been excavated. Although the evaluation of the status of specimens is not always conclusive in each case, the results indicate that, at the very least, probabilistic assessments can be formulated and valid lines for future research can be generated from such a study.

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This thesis could never have been completed without the assistance and access to collections provided by Bruce Raemsch and Jeffrey Goodman.

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laboratory space and equipment over the long winter months and summer research money to feed and clothe myself in the widely separated areas in which I worked.

In spite of all the assistance I received, I bear the final responsibility for any shortcomings in the final manuscript.

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I. Introduction

A. Problem Statement

The Folsom discovery more than 50 years ago substantially altered traditional archaeological concepts of the chronology of human occupation in the New World. Since that discovery, which demonstrated the coexistence of hominids with terminal Pleistocene fauna, little further progress has been made towards understanding the antiquity of human beings on this continent. Archaeologists are still unable to address meaningfully the question of possible precursors to people who produced the well-documented fluted point assemblages across North America approximately 11,500 years ago.

One of the most significant problems emerging from the largely unsystematic search for evidence of pre-Clovis hominids is that of distinguishing humanly-altered from naturally-altered stone and bone materials (Bryan 1978). This question is far from being resolved, although the evaluation of naturally versus culturally modified bone materials has been the subject of considerable research (Binford 1981, Bonnichsen 1978 1979, Morlan 1980), and the lines of argument, at least, well defined. The same cannot be said for the evaluation of natural versus culturally modified stone materials.

In most areas of the New World stone materials will constitute the bulk of the available evidence pertinent to the question of pre-Clovis hominids. Past trends projected into the future suggest that these materials will be most commonly recovered from secondary contexts (Drew 1978, Morlan n.d.). Although perhaps not the ideal context from which to evaluate the antiquity of hominids in the New World (Griffin 1979), appropriate techniques must be developed with which to evaluate questionable sites not in primary context (Morlan n.d.).

The focus of the present study is to lay a systematic framework for the evaluation of questionable stone materials in redeposited contexts. This goal will be achieved by construction of a general research design that incorporates the two most important parameters of altered stone materials: their geomorphic context, and the nature of alteration morphologies. In Chapters 4,5, and 6 case studies are presented which illustrate the application of the research design to the evaluation and assessment of stone assemblages from specific problematic sites.

B. The Pre-Clovis Problematic

To the casual observer, the numerous and often conflicting reports on the existence or non-existence of pre-Clovis assemblages in the New World must seem truly befuddling. On the one hand, laundry lists of pre-Clovis sites in North, Central and South America have been published (e.g., Bryan 1965, Krieger 1964, Sellards 1952, MacNeish 1976) most of which use the sites reviewed to erect cultural-historical frameworks of the evolution of stone tool technology. On the other hand, other scholars have reviewed the sites purported to represent evidence of pre-Clovis hominids and either dismissed the claims as unfounded or cast doubt upon a portion or portions of the evidence (e.g., Haynes 1969, Irwin 1971). Key issues cited in the non-acceptance of these sites include the following;

1. The dating and/or relative age assessment based on stratigraphic grounds is either inconclusive or invalid (e.g., Meadowcroft Rockshelter, Haynes 1980; Taima-Taima, Lynch 1974, Haynes 1969).

2. The argument for a pre-Clovis age rests entirely upon typological grounds in the absence of secure stratigraphic context or datable materials (e.g., Imlay Channel, Irwin 1971; Black's Fork Culture, Sharrock 1966).

3. The specimens are not of definite artifactual status (e.g., Calico Hills, Haynes 1973, Taylor and Payen 1979, Duvall and Veneer 1980; Medicine Hat Localities, Reeves 1980).

Although others have put forward other reasons for the non-acceptance of specific sites, such as an insufficient sample size (e.g., Tlapacoya, Haynes 1969), the problems outlined above probably cover the reasons for rejection of the vast majority of purported pre-Clovis sites in both South and North America.

Resolution of conflicting opinions regarding the first issue generally poses no great theoretical problems; either the stratigraphic evidence or dates based on reliable chronometric methods are present or they are not. Admittedly, problems can arise when otherwise reliable radiometric techniques are uncritically applied (Yuha

Burial, Childers and Minshall 1977), or when the age assessment is based on relatively untried chronometric methods (e.g., amino acid racemization dating of hominid fossils from California localities, Bada and Helfman 1975).

The second issue is fairly straight forward as well; simply put, dating entirely on typological grounds, shakey in the best of circumstances, is untenable for proclaiming a pre-Clovis age for specimens from a particular site. This is particularly true when there exists no well-dated cultural-historical framework with which to compare surface finds. Typically the typological argument is predicated on the premise that the cruder the artifacts the older they must be. The fallacy of this line of reasoning was successfully dealt with by Holmes (1919) earlier in this century.

This brings us to the third and final problem, which is the principle focus of this study: the discovery of principles for distinguishing artifacts from materials altered by a variety of biological or geological agencies. The artifact versus "naturefact" issue is a more complex problem in many ways but one in which archaeologists as 'experts in material culture' can hope to make meaningful general contributions.

C. Status of the Problem

This study has as its principle focus the problem of recognizing the human alteration of stone materials within the context of the dispute over human antiquity current in New World archaeology. Essentially this problem consists of an inability on the part of archaeologists to agree on the status of the primary data removed from sites(i.e., stone flakes and flaked stone objects). However, the general problem of recognizing the natural modification of stone has broader implications in terms of other materials (e.g., bone and ivory), and archaeological materials outside the New World. In addition, the problem is not always whether or not a particular assemblage of specimens constitute artifacts but, in some cases, whether or not artifacts have been subsequently modified by natural or non-cultural biological agencies.

In general, when purported artifacts from a particular site have been questioned with respect to their status as artifacts, it is not that the specimens don't *look* like artifacts, but rather, that within a given context it cannot be demonstrated that the specimens are *not* simply the result of natural processes. Most broadly-trained archaeologists recognize the great diversity that characterizes human stoneworking strategies throughout time and space. Given this familiarity, most archaeologists would not reject out of hand specimens recovered in a primary archaeological context no matter how crude or dissimilar from known artifacts an item or assemblage might be. It is only when the specimens occur within a geological context where flaking by natural agencies is a distinct possibility that questions of natural versus human modification are raised. Primarily, these contexts include secondary deposition of materials by one or more geomorphic processes.

D. Levels of Alteration

In this study, a distinction is made between two levels of modification of stone clasts by natural agencies. The analytical distinction between macromorphological and micromorphological alterations is made for two reasons, 1) a distinction between macro- and micromorphological alterations of stone tools has proved to be useful in the analysis of human alteration of stone (i.e., the analysis of stone artifact production and subsequent wear) and, 2) the qualitative difference between macro- and micromorphological alterations reflects real differences in the energy available in natural environments to produce alterations to stone clasts.

Macromorphological alterations consist of the removal of flakes or spalls greater than approximately 1 cm in length. Corresponding human behavioral inputs consist of a variety of production techniques including core-flaking and the shaping and thinning of specimens. An investigation of the natural production of macrogeomorphs is crucial for undertaking research into the question of "eoliths."

Micromorphological alterations include those attritional processes which result in the removal of flakes less than 1 cm in length, as well as a host of surficial alterations (formation of patinas, striations, pressure cones, etc.). In general, this arbitrary size limit would exclude much shaping. Human analogues to natural micromorphological alterations include primarily edge and surface alterations resulting from tool use and edge retouching.

In general, it can be assumed that where natural processes are competent to produce macromorphological alterations, the same process will lead to the production of micromorphological alterations as well. The nature of the micromorphological alteration will be for a given lithology dependent upon 1) the mechanism of transport, and 2) the nature of the physical and chemical weathering environment.

Eolithic controversies throughout the world represent attempts to differentiate natural macro-alterations from human stone-shaping. As such, the history of this kind of research spans more than a century, with surprisingly little real progress toward resolution of the problem.

Considerably less attention has been directed towards the consideration of natural micro-alterations (see however Stapert 1976). However, a number of use-wear analysts have acknowledged the problem of confusing natural edge alterations with that produced through use (Keeley 1974 1980, Keeley and Newcomer 1977, Semenov 1964). These authors suggested circumventing the problem by examining only those features produced through use and not characteristic of microalterations in natural contexts (e.g., edge polish). Other authors in the "edge damage school" recognize the problem of confusing natural edge alterations with attrition produced through use and have attempted to conduct relevant experiments to test the similarity in damage brought about by natural and cultural micromodifications (cf. Tringham et al, 1974).

E. The Eolithic Problem

The term "eolithic" was first coined by either G. de Mortillet or S.A. Brown during the late 19th century to describe what appeared to be the earliest attempts by hominids to manipulate stone (Oakley 1972). These materials, located in Tertiary deposits in England, France and Belgium (MacCurdy 1905), lacked the handaxes and flake tools characterizing the Paleolithic industries and were, by any standards, somewhat crude.

The question of the artificial status of these specimens was soon to be raised owing to the context of the specimens (drift deposits and pre-Quaternary gravels) and their lack of evidence of intentional modification. According to MacCurdy (1905: 433):

> The marks are often the result of use alone and not of design. This is due partly to the fact that people of that time did not know how to obtain the raw materials from the chalk, but depended entirely on picking up from the drift natural flakes of

approximately the shape and size needed.

Later, with continued research, other investigators began to turn-up flint implements that were apparently shaped to suit specific needs (e.g., rostro-carinates; Moir 1921). These supposed implements were held by Moir and others to be irrefutable proof of the existence of Tertiary hominids in Britain.

Although the existence of an Eolithic stage in Europe is no longer a hotly contested issue, the problem was never resolved to the satisfaction of several prehistorians. Once Warren (1905) described the evidence for the production of rostro-carinate forms by the natural pressure of overlying sediments, and others described the natural production of other Eolithic "types" (Breuil 1910) the issue largely died out.

Outside Europe, evidence of an 'eolithic' presence cropped up in widely separated areas such as Africa and Australia. The Australian Eolithic stage proposed by Howchin (1921) was quickly debunked by Jones and Campbell (1925) who observed the modern production of eoliths on the Australian Tablelands by natural thermal forces. In Africa, the controversy raged for some years until the excavation of undisturbed sites and the recovery of simple stone tools in primary context.

F. Contemporary Relevance

In a more comtemporary context, questions of natural micro- or macromorphological alterations have become central issues in determining the antiquity of Man, or the existence of specific archaeological cultures in widely separated areas of the world. Although the following discussion will focus primarily on the "eolithic" question in the New World, the intention is to demonstrate that this problem is not limited to this continent.

Macro-Alterations

Throughout major areas of the world such as Africa, Asia and Europe, there appears to be little difficulty at the present time in recognizing stone artifacts from the dawn of antiquity, even in situations where the material has been redeposited (e.g. Bartstra 1978), and the material is crude. In other more marginal areas (marginal in terms of temporal models of human colonization) either currently separated by large bodies of ocean (e.g., Japan or the New World) or in seemingly inhospitable areas of the world (e.g., western Siberia), the demonstration of the antiquity of man remains, at the present time, uncertain.

Interestingly, recognition problems have not occurred in Australia where a temporal record of over 40,000 years long has been demonstrated; despite the fact that Australia has always been separated from the mainland by a considerable expanse of open water (Hallam 1977). In this case, the temporal continuity in use of largely unstandardized stone tools has perforce lead to their recognition in a variety of contexts.

The New World Eolithic

The timing of the arrival of hominids into the New World has great significance for questions of cultural and biological evolution. In addition, the timing of arrival is central to our understanding of the role of hominids in the extinction of late Pleistocene megafaunal populations in North and South America (cf. Mossiman and Martin 1975). Current opinion is polarized into two camps; 1) those who see the earliest colonists crossing into eastern Beringia no earlier than about 13,000 B.P. (Haynes 1968; Lynch 1979) and, 2) those who feel hominids were already well established south of the continental ice sheets long before 13,000 B.P. (cf. Bryan 1978, Carter 1978).

The Martin/Haynes colonization model cites evidence for the sudden, widespread appearance of fluted, lanceolate Clovis points at around 11,500 B.P. in North America as the remains of a highly mobile initial colonizing population. Causally related to the initial penetration of North America by hominid big-game hunters in this model is the demise of over 35 genera of now extinct Pleistocene fauna. The latter model views the distinctive, widespread Clovis fluting tradition as an indigenous New World invention, developed in place in North America by ancestral human populations who first entered the New World perhaps as early as 60,000 years ago.

Central to our ability to evaluate these opposing models is the proper evaluation of those archaeological sites which pre-date 12,000 B.P. and do not yield fluted, lanceolate bifaces. However, although a fairly substantial number of sites have been put forward as evidence of a pre-Clovis occupation, relatively few have withstood the acid test of scrutiny by the archaeological community. Many of the sites advanced as candidates for a pre-Clovis occupation (such as those published in Krieger, 1964) have been surface sites where the argument for extreme antiquity has been on typological grounds. More tantalizing though, have been those sites where there exists independent dating for a pre-Clovis age but where general consensus cannot be reached regarding the artifactual status of the stone specimens.

The Problem of the New World Early Crude Stone Industry

Throughout North America, and large areas of South America, archaeological assemblages from virtually all time horizons include varieties of bifacially-thinned stone projectile points. This being the case, what did the stone tool repertoire of pre-Clovis populations consist of? This question has a bearing on the problem of distinguishing natural from humanly-flaked stone because our perception of what represents an artifact is conditioned by that with which we are familiar.

As there has been thus far little in the way of direct evidence to inform us as to the nature of pre-Clovis stone tool assemblages, inferences have been made on the basis of 1) possible ancestral populations in western Beringia and, 2) the poor quality lithic evidence in the New World. During the first half of this century it was common practice to extrapolate western European Paleolithic sequences to far distant lands. In North America, Renaud (1938,1940,1943) identified a corresponding sequence of technological development on the high plains of the western United States. Others have more realistically sought to derive early North American populations from central Siberia (Haynes, 1980, Workman 1980). Late Pleistocene assemblages there contain evidence of an advanced bifacial industry from which it is possible to derive the biface-thinning techniques of late Pleistocene Clovis populations in North America. Other persons see the early occupants of the New World as possessing what would be by North American standards a "crude" (i.e., less specialized) stone tool industry (e.g., Carter 1978, 1980, Bryan 1978). Chard (1959) proposed that early New World colonists were derived from the North Pacific Rim and brought with them a largely unifacial stone-working technology. Krieger (1964) echoed this opinion and went on to define what he termed the "Pre-projectile Point" stage in North and South America. Bryan (1978) has further developed Krieger's and Chard's position by inferring the existence of formerly more extensive wood and boneworking industries among the early colonists; these materials substituting for stone as the major material used for the manufacture of projectiles.

In Bryan's model, populations of hominids equipped with simple flake and uniface tools could have produced a wide variety of tools from perishable materials. Thus, the archaeological remains might consist of marginally retouched stone specimens with only a few of these being characterized by a high degree of flaking technology. In South America, a number of assemblages apparently fit these criteria (including Lapa Pequena; Bryan and Gruhn, 1979; El Abra, Hurt et al., 1976; Monte Verde, Dillehay n.d.;Los Toldos, Cardich et al., 1973).

Regardless of whether or not an ancestral, crude, stone industry is eventually established in the New World, this question poses a critical problem for New World archaeologists. Currently in North American archaeology it is common practice to interpret sites consisting entirely of flake tools as specialized activity sites (e.g., quarry workshops) or as incomplete ("the amateurs got the arrowheads"). Where assemblages of "crude" flaked stones are in a redeposited context the question of natural versus human flaking becomes extremely important. This issue is extremely significant when examining the likelihood of finding pre-terminal Wisconsin sites in an undisturbed context.

By contrast, in western Europe and the British Isles the vast majority of open-air Paleolithic sites are in redeposited contexts but most are easily recognized by the presence of carefully shaped tools. In this instance the specimens are morphologically similar to specimens collected from primary contexts on the continent, and exhibit a high degree of skill in flake removal.

The Paleolithic of Japan

Pre-ceramic archaeology in Japan began only in 1947 with the discovery and dating of the Iwajuku site (Morlan 1971). Since that initial discovery, which eventually established the reality of a Japanese Paleolithic, a large body of evidence has accumulated that securely dates the presence of hominids on the Japanese Islands at least as early as 30,000 B.P. (Ikawa-Smith 1978b). Apparently a land connection to mainland Asia existed before then, during the Early and Middle Pleistocene, that would have allowed easy access to the Japanese Islands by hominids present in Asia during at least the Middle Pleistocene (Ikawa-Smith 1978a). Although there exist at least 100 sites claimed to date earlier than about 30,000 B.P., the artificial status of the assemblages and/or their temporal position has been criticized, making the Early Paleolithic of

Japan at present an uncertain entity (Ikawa-Smith 1978a, Morlan 1971).

Morlan (1971) reviewed a number of the candidates for Early Paleolithic status in Japan (e.g., Sozudai, Hoshino, Fujiyama, Yamaderayama) and concluded that "... there appears to be no unequivocal evidence of a pre-Wisconsin maximum occupation of Japan (ibid., p. 164)." This conclusion is based primarily on the apparent "crudity" of the proposed artifacts. In only one instance did Morlan present an alternative explanation for the fractured clasts, where in the case of the Hoshino site, materials are suggested to have been fractured by transport in the Nagano River, in whose gravels the materials were deposited. At other sites (e.g., Fujiyama and Yamaderayama), Morlan states that the specimens in question are of nonlocal lithologies (ibid., p. 142), but rejects them as cultural products on the basis of their "amorphous form" (ibid.).

At the Sozudai site, northeastern Honshu, Serizawa (1978) claims to have recovered a variety of tool types (e.g. proto-handaxes, chopping tools) from an andesite gravel layer within the marine terrace in which the site is located. That the specimens are not as clearly man-made as suggested by Serizawa is indicated by Morlan (1971) who finds "...it difficult to find systematic evidence of human modification on these specimens (ibid., p. 141)". On the other hand, Bleed (1977) later analyzed the collection and claims to have found objective evidence for the artifactual status of the specimens

At the site of Iwajuku, further excavations located fractured clasts in deposits older than 40,000 years ago (Serizawa 1978, Ikawa-Smith 1978a). The artifactual status of these specimens is questioned by several authors (Ohyi 1978, Arai 1971, Arai cited in Ikawa-Smith 1978a). These authors base their criticisms on the grounds that the assemblage occurs in redeposited context in mudflow deposits with some evidence of solifluction. Similar arguments have been made against the geologically early Akabori Iso site (Ohyi 1978).

As seems common for "fringe" archaeological sites, evaluation of claims and counterclaims for and against the artifactual status of assemblages is made pointless by the lack of detailed analysis and description of relevant specimens. Rather, the argument becomes one of personal opinion, based on an intuitive feel of what is or is not an artifact.

Eastern Siberian Lower Paleolithic

The harsh climate of eastern Siberia has long been considered to have acted as a barrier to the human occupation of this area until the Upper Paleolithic (for a review see Derevianko 1978). Recently this basic assumption has been questioned on the basis of "crude" flaked stone found in redeposited early contexts by Okladnikov (1964, cited in Derevianko 1978). However, the contexts and technological "crudeness" of specimens recovered from fluvial gravels such as Filimoshki, on the Zeia River, have led to a certain degree of scepticism regarding the artificial status of the flaked stone specimens (cf. Klein 1971, Powers 1973).

Powers (1973: 16) cites the rounded ridges on flake scars of flaked stones as evidence for wear during transport in a fluvial environment. However, this explanation is unsatisfactory because, as with Acheulean artifacts in England, flaked stone artifacts having undergone fluvial transport would exhibit similar features.

Micro-Alterations

Natural micromorphological alterations do not often create interpretive problems for archaeologists on the scale of those potentially caused by natural macromorphological alterations. More often, micro-alterations affect the analysis of stone tool use where the alterations can sometimes completely obscure use-wear damage (Stapert 1976). However, in some cases, the possibility of micro-alterations can cause more severe interpretive problems.

In terms of eolithic controversies, natural micro-alterations on natural clasts can be incorrectly interpreted as human use-wear and/or retouch. At the El Bosque site, Nicaragua, for example, Gruhn (1978) addresses the question of human versus natural micro-modification of tabular chert fragments in geologicaly early deposits (Page 1978). Several of the specimens from this site exhibit sequences of microflake scars around their entire perimeter. If this damage could be confidently attributed to hominid activity, this site would be extremely important in the context of the New World early hominid controversy.

Elsewhere in North America, Morlan (1981) reports finding possible microdebitage in alluvial sediments in the Old Crow Basin. Employing a firm contextual argument, Morlan makes a compelling case for the human origin of these microflakes.

On other continents, the question of natural versus human micromodifications has significance for the possible misidentification of archaeological cultures. In France, the Tayacian and other pre-Mousterian industries have remained enigmatic since their initial identification. These industries lack the characteristic tool types (e.g., handaxs) of preceding and following industries and consist of flake tools with a characteristic steep retouch. More recently, archaeologists in France have come to consider these specimens to be "pseudo-outils" or flakes that have been subjected to a variety of turbation processes resulting in edge modifications resembling human retouch (Laville et al 1980). Probable mechanisms involved in the alteration of these specimens include bio-turbation or trampling (Bordes and Bourdier 1951) and cryoturbation (Laville et al., 1980, Bordes 1969).

The Clactonian occupies a similar enigmatic status in the British Paleolithic. Ohel (1978) has argued that the Clactonian does not in fact represent a separate cultural entity but merely redeposited Acheulean preparatory areas. Resolution of this dilemma rests in part upon the interpretation of edge damage on flakes in fluvial gravels ascribed to the Clactonian. In Ohel's (ibid.) opinion, much of the alteration is attributable to damage during fluvial transport and not hominid retouch.

G. Outline of Chapters

The introductory chapter has served to outline the problem under study and address its significance to general archaeological problems. In Chapter 2 a review of the literature pertinent to the question of distinguishing natural from culturally-modified stone materials will be presented. Due to the unsystematic nature of previous research, the literature is divided into three approaches: consensus, empirical/experimental and the technological approach. It is argued that much past research has suffered from the lack of a coherent, explicitly outlined research design. In the third chapter, a research design is presented which draws upon past research but emphasizes the necessity for evaluating the geomorphic context of specimens. In subsequent chapters three case studies are presented. These case studies consist of questionable altered stone materials collected from three widely separated excavation sites. In the concluding chapter the research design is evaluated in terms of its utility for evaluation of the case studies, and suggestions are presented for future research. It is argued that the most relevant area for future research lies in two areas: 1) obtaining a clearer understanding of the relevant parameters of transport in geomorphic environments through experimentation or empirical observation and, 2) development of process analogues for better understanding the human alteration of stone materials.

II. Previous Research

A. Introduction

The present chapter will review the relevant literature pertinent to the problem of distinguishing natural modifications of stone from those due to human activity. The structure of this chapter will follow the logical distinction made earlier between macromorphological alterations and micromorphological alterations. Macromorphological alterations were the subject of extensive research during the latter half of the 19th century and the early part of the 20th century when it was termed the "eolithic" problem. Much of current research into macromorphological alterations by natural forces has not progressed much beyond the foundations laid by earlier scholars. Micromorphological research, on the other hand, commenced only during the early 1960's with the renewed interest in obtaining functional information about stone tools.

B. Approaches to the problem: Macro-Alterations

Portions of the preceding chapter briefly outlined the nature of controversies about "eoliths" in both the New World and elsewhere. Throughout this discussion it became clear that several similarities in argument exist which serve to unify the nature of the problem throughout the world in the past as well as in more recent research:

1) In each area, questionable sites predate a specific time line beyond which archaeological cultures are firmly founded.

2) Questionable specimens generally occur in redeposited contexts.

3) Individual specimens or assemblages are relatively "crude" in comparison to the earliest generally accepted evidence.

Four not necessarily mutually exclusive approaches, or lines of argument, have characterized attempts to evaluate the status of various "eolithic" assemblages: the "consensus approach," the "empirical approach," the "experimental approach", and the "technological approach."

Consensus Approach

Perhaps the most widespread approach to the determination of the artificial or natural status of specific questionable assemblages has been the consensus approach, or the agreement in opinion by groups of scholars. Simply, though not unfairly put, this approach consists of groups of individual scholars examining a specific collection and its context, either personally or by communication, and arriving at a consensus opinion as to its status: cultural or natural. This does not, however, imply unity in the discipline as, quite commonly, two or more groups of scholars may reach quite different conclusions.

Obviously, the validity of this approach is dependent upon 1) the quality of data presentation and, 2) the competence of the individuals comprising the groups to make informed opinions on this subject. The impact of this consensus on the profession as a whole is, however, in direct proportion to the position and status within the academic community of the individual scholars and not neccesarily proportional to their competence in the particular field of study.

For example, it was consensus opinion by noted geologists (Sir John Prestwich, and Charles Lyell) from England that led, eventually, to the general acceptance of flaked stone from the Somme River gravels as being the work of ante-diluvial hominids (Oakley 1972). Similarly, it was an agreement in opinion by a majority of noted scholars that led to the general dismissal of the Calico Mountains site as valid evidence for very early hominids in North America.

At conferences in North America, a not infrequent sight is the excavator of an Early Man site, armed with a briefcase full of specimens, attempting to rally support for the authenticity of their discovery. This tactic consists of trying to stimulate grassroots support either prior to publication, or after this route has failed.

Clearly, the solution to a problem as complex as this cannot be resolved by personal viewing or handling of specimens. If the authenticity of specimens were so compelling as to convince a skeptic by visual examination, then the problem could be dispensed with in short order. In large part, the problem with the consensus approach lies its basic assumption: that archaeologists, as "experts" in the study of material culture, should be sufficiently competent to make informed opinions on the artificial status of a given assemblage of questionable flaked stone. The fact remains that the majority of archaeologists lack the requisite training to make a reasoned judgement on the basis of a limited visual or tactile impression, if indeed this is ever possible in marginal cases. Nevertheless, a number of sites, particularly in the New World, have had dark and ominous clouds cast over them on just these grounds (e.g., Calico Mountains, Texas Street, El Bosque). On the other hand, excavators of these potentially important sites have consistently failed to publish detailed documentation of their specimens and their contexts (see however, Meadowcroft Rockshelter, Adovasio, et al. 1977, 1978). More importantly, few scholars on either the pro or con side attempt to approach the problem from the framework of presenting for testing a series of multiple working hypotheses. It may be that there exists such an ideological split that neither side is willing to provide fuel for the alternative position.

C. The Empirical Approach

With the claims for an "Eolithic" technological stage during the latter part of the 19th century, archaeologists were presented with a very complex problem. On the one hand, the proposed collections of humanly-flaked stone were recovered from what were identified as Pliocene or Miocene deposits, earlier than the accepted existence of hominids anywhere: in addition, the specimens were exceedingly crude by Paleolithic standards. On the other hand, there existed little experimental or empirical evidence regarding the role of natural processes in flaking flint with which to evaluate these claims. Faced with this dilemma, prehistorians interested in the question of Early Man undertook an extensive program of empirical and experimental research into human and natural fracturing of stone.

Much of the empirical research, for reasons to be explained later, has been of small utility on other than a heuristic level. Thus, although there now exist many observations of natural flaking processes or their products, it is difficult to use these observations to make sense out of questionable early assemblages. There has been only one attempt (Barnes 1939) to pull together these varied observations into a coherent, empirically verified framework. Due to the extreme significance that the "Barnes method" has had in eolithic studies, this subject will be discussed at length below.

The primary contribution of empirical studies of natural fracture processes was the recognition that natural processes could, in fact, produce stone flakes and, in some cases, these naturally broken specimens mimicked hominid handicraft. Within the context of the Eolithic dispute, it was the "con" side that produced irrefutable specimens of naturally-fractured stone (cf. Breuil 1910, Rutot 1902, Warren 1905). These well documented studies, although not disproving the status of eolithic specimens championed by

Moir (1919) and others, cast sufficient doubt on the issue to keep it beclouded for years.

D. The Barnes Criteria for Human Workmanship

In the literature critical of proposed early sites in the New World, the most often cited study of natural fracturing is that of A. Barnes (1939). Essentially, Barnes' goal was to set up an objective, measurable index that would faithfully segregate populations of humanly-flaked stone from that flaked by nature (either pressure or percussion). Barnes set up his study by contrasting human and natural flaking in terms of the degree of control over fracture variables based on the premise that human work represents controlled fracture while natural flaking is uncontrolled, a distinction originally made by Warren (1905). Barnes quite rightly reasoned that a prime variable involved in the controlled removal of flakes is the angle between the platform and the core face. In percussion flaking, acute angles are an essential ingredient for most controlled flaking. From this observation, Barnes reasoned that collections of flaked stone "...may be considered to be of human origin if not more than 25% of the angles platform-scar are obtuse..." (ibid: 111). This seemingly arbitrary cutoff point was arrived at by comparing the angles platform-scar values from collections of humanly-flaked artifacts with specimens broken in situations of uncontrolled fracture (e.g., beneath the wheels of vehicles), and with collections of eoliths. In the latter two populations, the angles platform-scar values were consistently and significantly different (more obtuse) by at least one standard deviation than examples of human work.

Payen (n.d., Taylor and Payen 1979) has recently attempted to provide further empirical support for Barnes' generalization. Payen's study involved the collection of naturally fractured specimens from a number of different localitites, as well as conducting a series of experiments to fracture rocks in uncontrolled fracture environments. His study provides strikingly similar results to those obtained by Barnes (1939). Based on his results, Taylor and Payen (1979) published an evaluation of the stone specimens from the Calico Hills site. As specimens from Calico Hills exceeded the 25% cutoff for obtuse-angled flake scars, the authors concluded that stone clasts from the site were, in all probability, natural in origin.

The simplicity and intersubjectivity of the Barnes method has encouraged others to use the technique when evaluating questionable sites. Ascher and Ascher (1965) applied the method to specimens attributed to the Talchaco complex in Arizona. In their opinion, the Barnes technique successfully distinguished a collection of mixed surface specimens into populations fractured by nature from those fractured by hominids. Unfortunately, these authors made the initial segregation of specimens on the basis of other criteria, a logical error discussed further below.

More recently, Bleed (1977) modified the Barnes method to objectively assess stone flakes from the Sozudai site, Japan. Instead of measuring the angles of flake scars as Barnes (1939) outlined, Bleed measured the complimentary angle on the flakes (Wilmsen's 1970 Beta angle). In Bleed's opinion, the range of values obtained from the flakes indicate that hominids were responsible for their production as they conform to espected values for human industries from the Barnes index.

E. Problems With the Barnes Method

In a field as rife with controversy as that of Early Man studies in the New World, where opinion often outstrips analysis, an objective method for evaluating questionable sites such as the Barnes method would seem to be a cure for the ills of the field. However, certain criticisms of the method have been raised. These criticisms make it unlikely that the Barnes method will ever achieve the status of a discriminating technique which is applicable in all places at all times.

Speth (1972) argues that when dealing with as complex a phenomenon as stone fracture, concentration upon a single attribute could be dangerously misleading. However, this criticism would be valid only if the method remained unsubstantiated by any particular body of empirical data. More serious are several criticisms outlined below that have to do with the logical structure of the Barnes method.

Essentially, the Barnes method represents an empirical generalization, that is, a summary statement based on observed patterns in sets of empirical data (Reynolds 1971). The explanation for the relationships observed in the data resides in the postulated differences between controlled and uncontrolled fracture. The relationship between data sets is not subject to question, only to further verification. The real problem lies in the postulated relationship between uncontrolled fracture and human versus natural fracture.

That the human fracture of stone is not always controlled in Barnes's sense has been illustrated by White's (1967) study of aboriginal stoneworking techniques in New Guinea. In this instance stone was reduced to angular fragments by simply throwing one large nodule onto another. Similar practices have been observed among Australian aborigines. Although no analysis of flaking angles have been published from these studies, it is most probable that ranges of values for these attributes would conform to the uncontrolled, or natural fracture model.

On the other hand, it is relatively easy to demonstrate the existence of certain stone reduction strategies where the resultant by-products are characteristically steep or obtuse-angled. For example, aboriginal craftspersons characteristically reduced rounded quartzite cobbles and pebbles with various bipolar reduction strategies. These stoneworkers readily manipulated radial fracture principles (Bonnichsen 1977) that invariably yielded obtuse-angled by-products. The well-known blade industries in Europe were predicated on the attainment and manipulation of steep-angled core faces with resultant steep-angled debitage.

Clearly, Barnes's (1939) concept of controlled fracture cannot be extended to all known hominid strategies of stone tool production. Rather, his method is only verified for those stone industries from which it was drawn, primarily Acheulean and Mousterian. However, the method could logically be extended to most other stoneworking strategies where cone fracture techniques and bifacial flaking predominate.

Uncontrolled fracture, either natural or experimental, was found by Barnes (1939), and later verified by Taylor and Payen (1979) to yield obtuse angles platform-scar values in at least 25% of the examples. Mean values obtained from these data range between 84 degrees and 99 degrees for various sample lots. As a flintknapper, this distribution of values is contrary to experience (see also Patterson n.d.). The reason human beings utilizing cone fracture principles generally impact upon acute-angled core faces is because this is the easiest means of reducing a core. With only a hand held impactor it is difficult to drive off flakes, let alone control their morphology, from obtuse-angled core faces. Therefore, if the responsible mechanical principles operate at all times, why should natural forces be immune?

The data on uncontrolled fracture presented by Taylor and Payen (1979) and Barnes (1939) can be explained by examining the force levels represented by the natural and experimental environments from which their specimens were collected. The only way in which hominids are able to manipulate radial fracture techniques is either by throwing a large rock onto another, which is fixed upon an anvil, or by using a sufficiently small pebble on an anvil. Thus, variables such as force and size of the impactor relative to the impacted clast are crucial and, beyond a theoretical threshold, the angle of the impact area relative to the core face is not important.

Therefore, in natural environments where energy levels greatly exceed the threshold failure limit of particular stone clasts, fracture can occur regardless of the angles presented by impacted clasts. This postulate is verified by experimental and natural contexts from which Barnes (1939) and Payen (Taylor and Payen 1979, Payen n.d.) selected specimens. These fracturing environments include: glacial deposits (Barnes 1939, Taylor and Payen 1979), collapsed beds (Barnes 1939, Taylor and Payen 1979), roadways travelled by heavy vehicles (Barnes 1939, Taylor and Payen 1979), dropping 50 lb weights onto chert nodules (Taylor and Payen 1979), and crushing with an eight ton road grader (Taylor and Payen 1979). Clearly, in these situations the internal strength of the rocks is greatly exceeded and the angle of fracture will depend upon the availability of angles of different degrees and the specific area impacted. In natural environments where available energy exceeds this theoretical threshold value then Barnes's axiom will probably hold true.

Most natural processes probably do not exceed this threshold with great regularity. Fluvial processes certainly would not fit this pattern. Fluvial environments are characterized by a wide range of energy levels both seasonally and longitudinally along their course. However, other than waterfalls, it is unlikely that anywhere along their course would they regularly exceed threshold strength levels for most rocks. Similarly, various soil creep processes probably do not exceed these limits. Under these conditions, when and if macromorphological alterations occur, they should conform more closely to the controlled fracture situation (i.e., less than 25% obtuse-angled removals). Thus, Barnes's (1939) criteria for distinguishing natural from humanly-flaked stone cannot be applied across the board, at least not without further empirical data from environments of alteration not characterized by energy extremes.

A further impediment to the uncritical application of the Barnes method lies in the inherent assumption by most workers that a particular collection of flaked stone will be *either* natural *or* human in origin. It is entirely possible that certain redeposited sites may contain specimens fractured by both natural and human agencies. In a mixed situation like this, where populations of specimens produced by one process greatly outnumber the other, the Barnes method would simply recognize the more dominant population. Without some independent means of segregating populations of artifacts from naturefacts, the Barnes method would possibly mask the presence of independent populations. Thus, at a site such as Calico, where natural processes have surely produced a significant portion of the fractured stone in the deposits, it is inappropriate to adopt a single variable approach like the Barnes method as Taylor and Payen (1978) have done to evaluate as complex a question as natural versus human fracturing. In order to resolve the origin of questionable assemblages a method of multiple working hypotheses must be adopted that includes consideration of both natural and human origins.

F. Statistical and Population Arguments

A commonly heard assertion against acceptance of many proposed early sites in redeposited contexts is that the excavator has failed to collect a truly representative sample of clasts from the site and simply selected a small number of specimens that, by chance, resemble artifacts, from the total range of variability in clast morphology (Comments in Cole and Godfrey 1976). Duvall and Veneer (1979) term this practice "form selection," defined as "...the selection of naturally fractured lithics that resemble man-made tools and therefore create a biased sample of lithics from the total population of naturally fractured lithics at the site(p. 455)."

As Patterson (n.d.) points out, this reasoning "... is based on the assumption that if nature breaks enough rock, significant amounts of specimens resembling man-made objects can be produced (p.4)." In Patterson's (n.d.) opinion this is an unconfirmed assumption. As he goes on to point out, if there are great quantities of rock in the deposits then it becomes a matter of practicality to invoke initial screening procedures to select only those specimens that *may* be man-made.

Clearly, if subsequent analyses are to be framed in terms of statistical comparisons of either attributes or specimens, then at least control samples encompassing the total range of natural variability must be collected. This kind of methodology was employed by excavators at the Calico Hills site, as well as in the case studies in the present study.

Duvall and Veneer's (1979) study has been justifiably criticized on several grounds that have significance for the design of tests to distinguish hominid-fractured from naturally-fractured stone. The first issue revolves around the selection of attributes of broken stones with which to compare populations. The second issue involves the question of what populations of "other" specimens should questionable specimens be compared to. A final issue can be raised regarding the image of ranges of specimens along some hypothetical normal curve from "naturefacts" to "possiblefacts" to look-alike "artifacts".

The selection of attributes, as in the testing of any proposition, is crucial if the results are to be meaningful with respect to the proposed alternative hypotheses. As Patterson (1979) has argued, the greater portion of attributes selected by Duvall and Veneer (1979) are among those least likely to be significant in the determination of natural versus human flaking. These attributes consist mainly of those which describe the overall geometry or the geometry of specified edges of specimens. In demonstrably human assemblages, ranges of values for these attributes can be shown to differ, significantly, as a function of cultural factors (e.g., quarry sites versus hunting camps) and characteristics of the raw materials involved. Clearly these authors have chosen to select those flake attributes amenable to facile quantification rather than grounding the selection of attributes in terms of underlying principles: specifically the principles of fracture mechanics and general patterns of human stoneworking strategies. Certainly attributes of flake geometry have their place in a descriptive study of the sort undertaken by Duvall and Veneer, however, not in a strictly comparative argument as the authors presented. Rather, variables or attributes must be consciously weighted in terms of underlying principles of stone fracture.

In the chapter to follow, flake attributes that are useful in forming evaluative statements of human versus natural fracture are discussed. These attributes are then related to properties of stone fracture as discussed by several authors (e.g., Speth 1972, Bonnichsen 1977), and to the principles of human stoneworking (Phagan 1976, Bonnichsen 1977).

Patterson (1979) and Gruhn and Young (1980) have successfully rebuked Duvall and Veneer's (1979) use of inferential statistics in comparing the proposed tools from Calico with Paleo-Indian flake data presented by Wilmsen (1970), and the Calico site control group specimens. As these critics point out, whether or not flake thickness, length or width are statistically different from that derived from classic Paleo-Indian sites is of no consequence to the issue of whether or not the Calico specimens are artifacts. This fundamental problem of inappropriateness relates to the problem of attribute selection discussed previously, as well as to the fact that the eight Paleo-Indian sites discussed by Wilmsen (1970) are hardly representative of human stone-flaking in the New World during the last 10,000 years, let alone a much earlier time. What then is the value or appropriate place for comparisons of population characteristics in tackling the issue of human versus natural flaking?

An obvious solution to this logical dilemma would be to compare populations of possiblefacts to specimens known to have been fractured by geological agencies similar in kind to those represented at the site in question. This sort of analysis is performed for specimens at the Timlin site and Caribou Island site (Chapter 4) where fracturing can be demonstrated by independent means to have occurred during glacial transport. However, it must be recognized that this is generally a difficult problem to overcome, as, in most instances of natural fracture, geological processes do not leave independent lines of evidence on flaked specimens.

G. Technological Approach

One of the early arguments put forward by Moir (1912, 1919) for the artificial status of English eoliths was that morphological "types" could be isolated in these collections and that they represented a replicable production strategy. One half of the argument consisted of simply demonstrating that hominids could, in fact, create stone objects of similar morphology. To this end, Moir (1912) performed replicative experiments demonstrating the way in which rostro-carinate implements could be manufactured using only simple stone tools. Given the state of knowledge regarding stone tool manufacture around the turn of the century these studies were an essential part of the attempt to understand the problem. The final part of the argument was that these morpho-technological types recurred consistently and formed a pattern of both shape and technology.

Unfortunately, demonstrating how a particular 'implement' could have been manufactured by hominids does not mean that hominids actually manufactured such a 'type.' Warren (1921) countered Moir's (1912) claim by demonstrating how, in certain natural contexts this form and "technology" could be replicated. At this point the argument enters the realm of probabilistic assessment. What is the rate of occurrence in a given locality of specific "types," for instance the rostro-carinate, in relation to numbers of other clasts of flakeable stone? Unfortunately, these studies were never undertaken and the issue was left to be resolved through consensus.

Clearly though, the demonstration of how an implement *could have been* manufactured is an important step in resolving its artificial or natural status. Recently Childers (1977) has succeeded in replicating one method for the production of what he calls "ridge back tools," found in the deserts of southern California. The technique outlined by Childers consists of a two person operation using a large wooden punch impacted on a large stone cobble to drive large spalls off a boulder. This process functions to isolate a platform for the removal of a large flake with a triangular cross-section. The end product lacks morphological features such as a platform and bulb of percussion that are characteristic of most stone flaking. As this technique is extremely dissimilar to typical North American aboriginal stoneworking techniques, in the absence of contextual evidence to the contrary, an unmodified "ridge back" would likely be dismissed as an artificial specimen.

In a similar vein, Bonnichsen (1968) demonstrated a recurrent pattern of producing flake geometrics on the Northern Plains by radially fracturing flakes on an anvil. Prior to this study, broken, angular flake fragments were commonly attributed to geological or accidental biological breakage.

Clearly these sorts of analyses are of value on a heuristic level. Certainly the principles involved in this form of reasoning (recurrent patterns of form and technology) form the basis for the recognition of all archaeological assemblages. In the case of bifacially-flaked implements in the New World, it is both the almost pedantic recurrence of form and technology as well as the intuitive assessment of the improbablity of a natural origin (due to the expertise required consistently to produce bifacial implements) that makes is possible to identify a Clovis point even in a redeposited context. Replicative studies of techniques of production can, therefore, be of great utility in at least providing a sense of understanding regarding the steps and difficulty involved in specific production strategies.

Attribute Analysis of Manufacturing Patterns

The majority of questionable assemblages of flaked stone do not consist of heavily modified stone clasts. Rather, these collections consist primarily of stone flakes, flaked nodules, and minimally modified clasts. In these situations, a technological analysis focuses on attributes of flakes or flaked nodules that are characteristic of human stoneworking and defines their range of values and occurrence on specimens in the collection. These attributes include platform preparation, numbers and patterns of dorsal flake scars for flakes, and angles directions and uniformity of flake scars on flaked nodules. An assessment of the collection can then be made on the basis of assumptions of patterning and regularity in human flaking, and its absence in natural fracture situations (Patterson n.d.).

Surprisingly, however, few studies of this sort exist. Clearly the documentation of attributes of stone tool manufacture should form the basis of any detailed analysis of a collection of questionable specimens from a particular locality. At the very least, this sort of detailed analyis would provide information with which the archaeological community could begin to make informed decisions.

Patterson (1977, n.d.) has performed preliminary analyses of manufacturing attributes for the Texas Street and Calico Hills collections. Although a useful first step, Patterson examined only small portions of the collections and the data were presented only sketchily. In addition, Patterson (n.d.) has prepared a detailed discussion of the significance of particular attributes, or attribute states, in recognizing human modification of specimens in disturbed contexts.

Other studies pertaining to manufacturing pattern evaluation are even less quantitative (cf. Witthoft 1955). These studies attempt to recognize general manufacturing strategies (e.g., bipolar flaking) without providing evidence to support the observations.

H. Evaluation of Micromorphological Alterations

Introduction

The previous chapter has outlined some of the problems encountered with micromorphological alterations on a macroscopic level which can imitate either use-wear or human retouch. The discussion to follow will focus on the empirical and experimental work undertaken to attempt to resolve this issue. As will be shown, the debate about the possibility of distinguishing certain kinds of micromodifications has resulted in a methodological split among use-wear analysts that will only be resolved with further experimental and theoretical studies. This split has been termed the "low power approach" versus the "high power approach."

In a pioneering experimental and systematic approach to the application of use-wear studies to stone tools, Semenov (1964) pointed to the possibility of natural edge and surface modifications either mimicking or obfuscating evidence of human use-wear. This work was concerned primarily with the observation of microscopic alterations. Since Semenov's study, which actually reiterated statements made by Warren (1914), several authors have concerned themselves with developing criteria for distinguishing human from natural micromodifications (cf. Ohel 1979, Isaac 1977, Keeley 1980, Tringham, et al. 1974).

The majority of natural micromodifications (e.g., microflake scars) require only small amounts of energy, and very little or, in some cases, no movement of clasts (e.g., solution polish). Given these energy and movement parameters, some natural micromodifications should be expected at almost any archaeological site, making this field of study of extreme importance.

The "High Power" Versus "Low Power" Argument

It has long been recognized by archaeologists (cf. Moir 1919, MacCurdy 1905) that when human beings utilize stone tools to perform tasks such as scraping, chopping or cutting, both microscopic and macroscopic alterations to the tool edges and surfaces can occur. These alterations may take the form of microflaking of the edge of the tool, or a host of other morphological features, including edge polish and the formation of striations on surfaces. However, it was also recognized that natural agencies could produce many of these same alterations.

With the emergence of lithic use-wear studies as a potent research field, a methodological split has arisen, centered, in part, around the issue of distinguishing natural from human microalterations. Keeley (1974, 1980, Keeley and Newcomer 1977) has been perhaps the most persuasive proponent of the "high power" approach to use-wear studies. Advocates of the the high magnification approach echo Semenov's (1964) original concern that a number of natural agencies can produce edge and surface alterations morphologically similar to human alterations. Keeley (1980; 29-35) feels that edge polish and to a more limited extent, striations, provide the only reliable indicators of human utilization. Thus, in his opinion, analysts who rely primarily upon low magnification will be apt to misidentify a number of natural modifications as being caused by human utilization.

Proponents of the low magnification approach argue that their methodology is both faster and less expensive than primary reliance upon high magnification observations. They argue further that edge damage, in the form of microflaking, occurs much more rapidly than either polish or striation formation and that specific tasks performed on materials of variable hardness will leave characteristic patterns of edge damage (Odell 1980, Odell and Odell-Vereecken 1980). To counter criticisms laid by proponents of the high power approach, a limited series of experiments were undertaken to replicate the formation of edge damage by natural agencies. These experiments led Tringham, et al. (1974: 191) to make the unqualified statement that:

> "in analyzing the lithic material of a prehistoric assemblage, there is no difficulty in distinguishing the damage resulting from deliberate usage from that which results from accidental or 'natural' agencies."

In their replication of fluvial transport the authors cited above subjected five flint flakes to vigorous shaking in a plastic bag filled with sands, gravels and water for one hour. The conclusions derived from this experiment were that damage from water action is distinct and "...quite unlike any known wear pattern (ibid.)." Characteristics of this pattern produced by 'natural forces' are as follows:

1) Random distribution of scars along the entire flake perimeter,

2) Random orientation of flake scars,

3) No standardization of size or shape of scars.

In addition, the authors performed a trampling experiment in which flakes were shallowly buried and the experimenters jumped and trod on them for several hours, with the following results:

1) Random distribution of scars around the entire perimeter, but only on one surface.

2) No fixed orientation or size of scars.

The identification of micro-alterations that could only have been produced by human activity would be of great utility in disputes over questionable assemblages. Polish (as emphasized by Keeley 1980) may well prove to be one of the few variables that can be confidently assessed (cf. Stapert 1976). However, in the contexts in which the majority of questionable sites are located, evidence of edge polish may be entirely or partially obliterated. Stone flakes subjected to water abrasion can have their edges rounded relatively quickly, thus obscuring any evidence of use-polish (Appendix I). Thus, although it may be possible to recognize features altered by natural agencies, as Keeley (1980: 30) suggests, it is often impossible to determine if prior human traces have been subsequently removed.

The criteria developed for distinguishing natural from human micromodifications by the low power school consist of differences in the patterning of morphology, direction and placement of microflaking. These differences are based on very limited experimentation and on assumptions of how clasts are transported by natural agencies.

Keeley (1980: 30) has criticized the experimental replication of fluvial transport undertaken by Tringham, et al. (1974). As in the case of the Barnes method discussed previously, researchers tend to confuse natural processes with a notion of randomness in force amounts and placement of impact points. However, as Keeley (1980) points out, the presence of water is not a sufficient condition for the imitation of fluvial transport. As discussed in Appendix I, fluvial transport is far from random in the sense used by Tringham, et al. (1974) and is capable of producing damaged edges characterized by uniformly spaced, parallel, equal-sized flake scars.

Most archaeologists operate with the assumption that natural forces will produce random arrangements of edge damage. In the majority of natural environments this is probably a valid assumption. However, around the turn of the century Warren (1905) demonstrated empirical evidence for the natural production of flake scars on specimens that were uniform in size, orientation and direction, by sub-soil pressure flaking. However, this type of damage may well be of low probability. In other environments, where fluvial transport of clasts has operated, randomness cannot be assumed. Further, Flenniken and Haggarty (1980) have observed how simple trampling of clusters of flakes can yield edge damaged specimens that closely resemble those documented from prehistoric assemblages.

I. Summary and Discussion

This chapter outlined three general approaches to the evaluation of macromorphological alterations to assemblages of flaked stone. Because of the lack of a coherent research design for the evaluation of questionable assemblages, archaeologists have usually operated by means of the process of consensus opinion. This approach has not only been unproductive but counterproductive to the ultimate resolution of the status of potentially significant sites.

The empirical/experimental approach has proven useful as far as it has been taken. Useful examples of alterations to stone clasts have been described. In addition, the Barnes method was formulated out of these studies, providing a measurable index of, unfortunately, questionable utility when employed in isolation without other analyses.

The technological approach is promising though untested against significant bodies of data. This study maintains that presentation of technological data is a necessary first step in the evaluation of questionable sites.

In the following chapter the empirical/experimental and technologicals approach are synthesized into a coherent research design for the evaluation of questionable assemblages. These approaches when combined with the contextual parameters of specimens form a synthetic research design with which meaningfully to evaluate questionable assemblages of modified stone.

III. Research Design

A. Introduction

Earlier sections outlined the significance of natural alterations to stone clasts for a series of archaeological problems. Previous approaches to the problem of macro- and micromorphological alterations were reviewed. In general, the majority of these attempts were found to be inadequate; authors either made invalid primary assumptions concerning populations of specimens or applied faulty and inappropriate analytical procedures. In the present chapter, a research design is outlined for the evaluation of questionable sites. This design differs from those of previous studies in its emphasis on the contextual parameters of specimens as well as a systematic evaluation of technological aspects. A final section discusses evaluation procedures for questionable sites.

B. Epistemological Considerations

There is no difference between the fracture mechanics of human and natural flaking per se. A blow of a given magnitude, delivered by an impactor, to a portion of a nodule will produce a flake of identical proportions whether resulting from human hands or natural force. A similar logic is appropriate to situations of static loading.

Even in redeposited contexts, archaeologists apparently have no difficulty determining that bifacially-thinned stone specimens are of human origin. If a North American biface or Acheulean handaxe were found in coarse fluvial gravels, or even glacial till, most archaeologists would have little trouble identifying the agent of production (e.g., Stapert 1976b). The number of individual events represented on the specimen (number of flake scars), the inference of intentional shaping, and the known difficulty, even for humans, in removing long, thin, bifacial-thinning flakes contributes to this unquestioned appraisal. However, this is merely a probabilistic assessment based on empirical observations of flint-working, and on observable patterning in form and technology. The probability of human alteration of bifacially-thinned and shaped stone specimens would be high. However, recognition of bifacially worked stone objects as definite human products was not always so clear cut as evidenced by the early controversies over handaxes in redeposited contexts (Oakley 1972). Much of what is considered a definite human product results from previous experience and familiarity with similar forms. On the other hand, the Australian example has indicated that even less extensively modified stone specimens become definite human products when they are are the dominant artifacts in primary contexts.

At the other end of the spectrum are specimens and features that can be assumed, with a high degree of probability, to be of natural origin. These include frost spalls and a variety of surficial alterations such as deep, heavy striations, surface percussion cones and various cryoturbation alterations (i.e., localized blunting and polishing, Stapert 1976).

Between the ends of this spectrum lies a gray area in which probabilistic assessment is difficult and requires detailed analysis and thoughtful consideration of alternative modes of alteration. However, it should be possible, where the appropriate conditions of sample size are met, to evaluate assemblages of flaked stone and make assessments regarding their origin in probabilistic terms.

C. Research Design

Implicit in the evaluation of questionable sites are two primary considerations: the context of specimens and stone artifact technological criteria. In previous studies, excluding Reeves's (1980), contextual criteria have been used to argue against a hominid origin, and technological/typological criteria used to argue in its favor. However, in order adequately to assess doubtful specimens, both contextual and technological criteria must be considered from an objective perspective. Only then will it be possible to carry out a probabilistic assessment. The primary aspects of this research design will be discussed first. A more expanded discussion is presented later in this chapter.

There are three primary components to the research design outlined in Figure 1: data recovery decisions, evaluation of contextual parameters, and technological evaluation. The first component, data recovery decisions, will determine in part the nature of subsequent analyses that can be carried out. Contextual evaluation provides the starting point for hypothesis formulation regarding the nature and extent of natural alterations. Technological evaluation involves the observation of the alterations to stone specimens. From these evaluations, assessment is carried out with respect to the fit between formulated hypotheses and results from the analyzed data.

A degree of feedback exists between all components of the research design. Data recovery decisions made at the beginning of excavation must often be mitigated in light of hypotheses generated from the other components (see Chapter 4 and 5). Thus, for example, additional natural processes may be inferred from the contextual evaluation. This may entail collection of non-artifactual specimens from the site deposits. A similar strategy was employed in the Calico Hills project (Simpson, et al., 1978). Hypotheses generated from the contextual or technological evaluation may require off-site data collection. In this case, either experimental data collection or recovery of materials from similar environmental contexts may be required (see Chapter 4).

In most previous cases, data collection has proceeded in the absence of an explicit research design. This has left many site analyses/evaluations open to the criticisms outlined in Chapter 2: that the excavators have merely

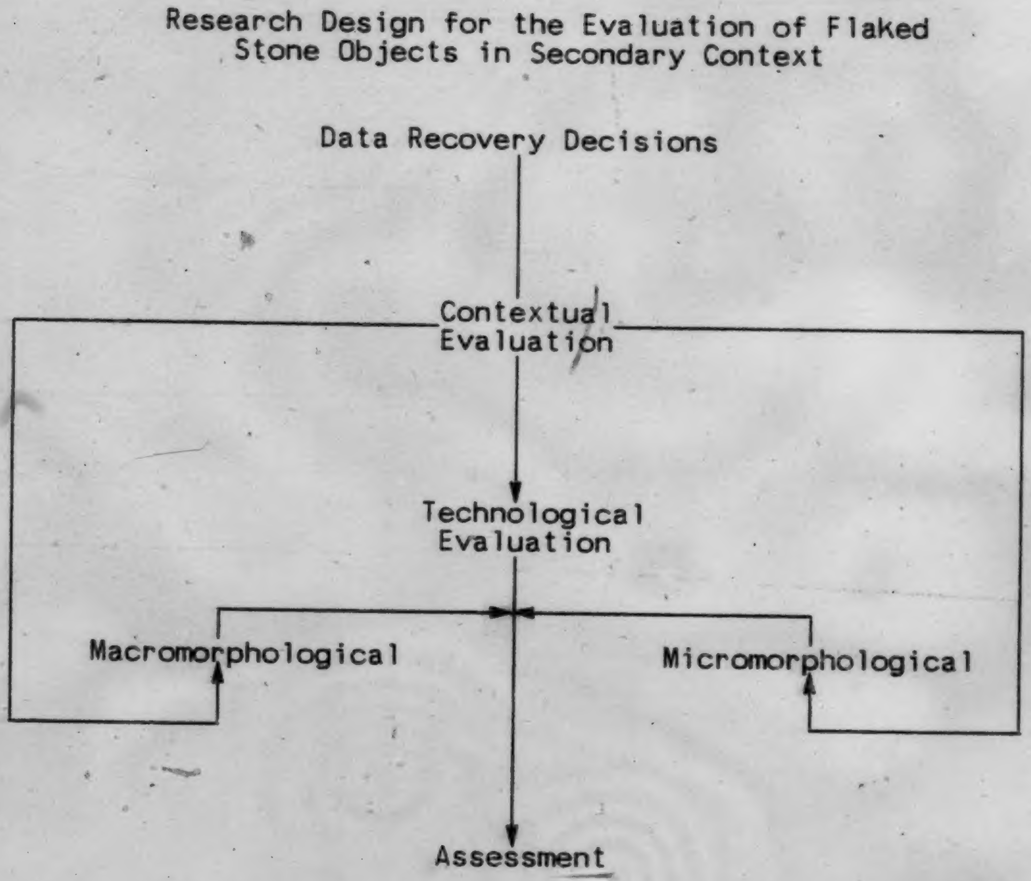
Research Design for the Evaluation of Flaked Stone Objects in Secondary Context
Data Recovery Decisions
Contextual Evaluation
Technological Evaluation
Macromorphological
Micromorphological
Assessment

Figure 1. Research design for the evaluation of flaked stone objects in secondary context.

selected end-members of a continuum of natural fracture products. In addition, unsystematic data collection precludes many potentially important comparative analyses (see Chapter 6) and, hence, weakens the conclusions that can be drawn from them.

Contextual evaluation influences data recovery decisions and the nature of data observation in technological evaluation. This is because hypothesis formulation stems from the evaluation of the contextual parameters of specimens. As an example, for specimens collected from areas characterized by extreme temperature ranges, spalling of clasts by freeze-thaw action may be an appropriate working hypothesis. This hypothesis can then be tested against the data. Additionally, this hypothesis, if substantiated, may require placing lower confidence limits on certain technological attributes (e.g., dorsal surface scars). Alternatively, certain alteration products may be deemed to be anomalous from the standpoint of the contextual evaluation. This may require additional contextual evaluation or strengthen the alternative hypothesis of a human origin for the specimens.

Technological evaluation consists of observation of alteration attributes on specimens that are characteristic of human stoneworking but not mutually exclusive of natural alterations. In this evaluation, close interplay must exist with hypotheses concerning natural alterations generated from the contextual analysis. The contextual evaluation provides a basis for placing confidence limits on observations from the technological evaluation.

The preceding discussion has served to outline the primary components of the research design and their interrelationships. The individual components are expanded more fully in following sections.

D. Collection Procedures

Collection methodology is extremely important to the resolution of the artifactual status of a collection of altered stone specimens. If a case is to be made for the artificial status of altered stone clasts in a secondary context, it must be demonstrated that the specimens are anomalous products for their reconstructed geomorphic context. This case can only be made if, 1) samples of known natural alteration products are systematically collected from the site deposits or, 2) specimens can be compared with relevant published or experimental studies.

Arguments against the procedure outlined above are that it is too expensive and time-consuming in terms of field and laboratory work (Patterson n.d.). However, collection procedures for artifacts as well as geofacts can be implemented in terms of an overall research design. For example, if in the deposits of a site the great majority of specimens are angular or rounded unflaked clasts, then only a small representative sample may need to be collected. In this instance, the relevant information to be gained from the analysis of naturally altered clasts might be only a description of the size range of clasts (for comparison with suspected human flakes), and the relative abundance of particular size classes or lithologies in the deposits. However, in situations where there exists an abundance of flaked nodules and flakes, in-field segregation is dangerous, and a large sample should be collected for comparative purposes.

E. Contextual Analysis

Contextual here refers to the reconstructed geomorphic and weathering environment in which specimens were located and underwent transport or disaggregation. From this analysis, an appreciation can be gained for the potential of various kinds of macro- and micromorphological alterations. This can be achieved by a consideration of models of particle transport via various geomorphic processes, as well as those alteration mechanisms that do not necessarily include significant transport (i.e. physical weathering).

The underlying rationale for carrying out a contextual analysis is that not all geomorphic processes transport specimens in the same way. Various processes can selectively bias the representation of certain size classes (Shackley 1978, Isaac 1967), or lithologies. In addition, the kinds of alterations characteristic of particular environments can be rather different due to the manner in which specimens are transported. For instance, in a fluvial environment, the nature of particle movement and, hence, damage, is in large part dependent upon size and to a lesser extent, shape characteristics. Further, the amounts and distribution of energy available in particular environments differs greatly and will therefore affect the nature and kinds of alterations to specimens.

Energy levels can be thought of in terms of the competence of natural environments to produce given alteration types. Figure 2 depicts a hypothetical continuum of transport energy in geomorphic environments. Environments below the hypothetical dashed line are primarily involved in producing micromorphological alterations to stone clasts and artifacts. Those above the line are involved in producing both macro- and micromorphological alterations. The transport energy, and hence the competence, of a given alteration environment will determine the range of alterations produced in terms of size and morphological characteristics.

The empirical data upon which Barnes (1939) formulated his criteria as well as the later study undertaken by Taylor and Payen (1979) was derived from specimens fractured in environments located above the line on Figure 2. These environments are characterized locally by abundant available energy greater than that required for clast failure. Thus the large percentage of obtuse angled flake removals, seemingly anomalous from a flintknapper's perspective, makes sense when considering forces beyond those capable of being

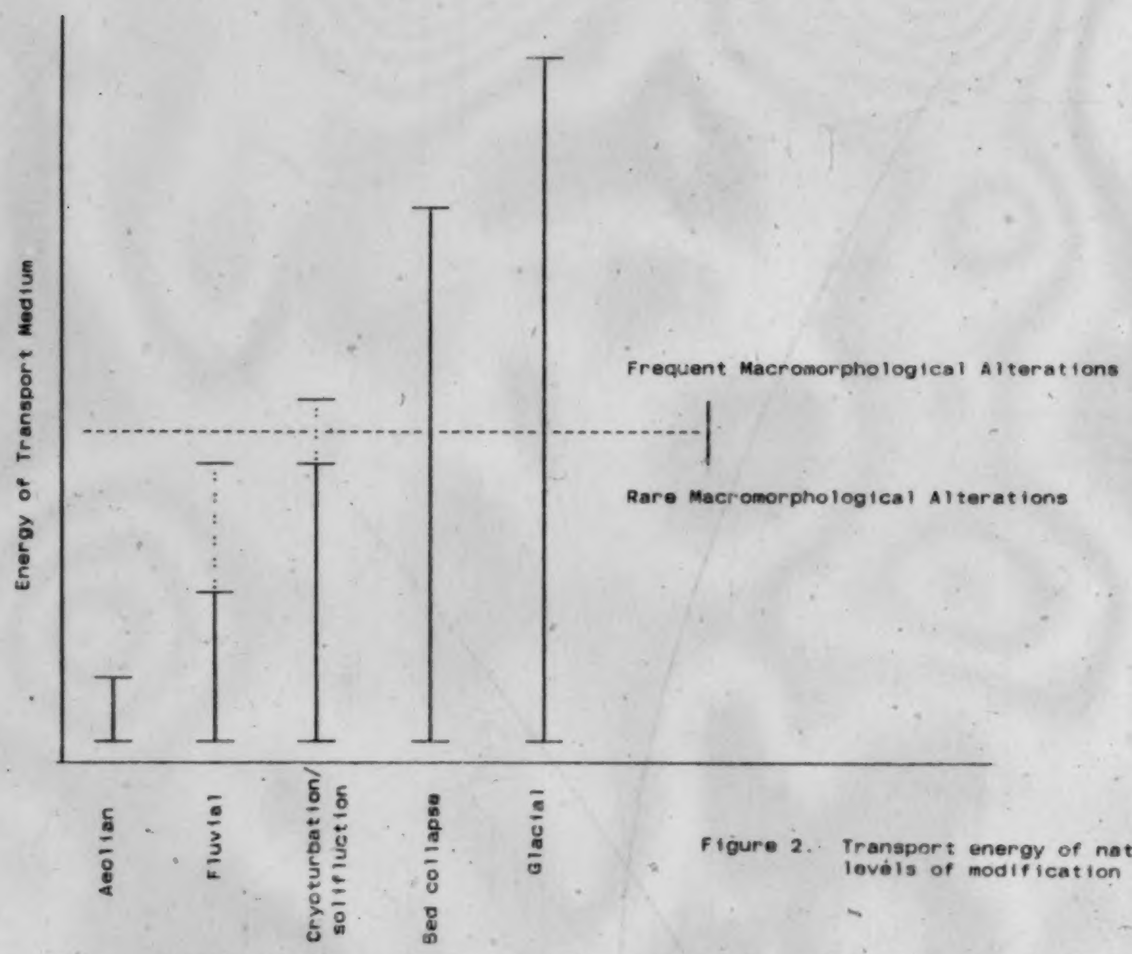

Figure 2. Transport energy of natural environments and levels of modification to stone clasts.

Note: No scale is given on the X axis because energy values for various natural environments have not been quantified. Thus the hypothetical ranges of values given here are estimates based on the empirical evidence cited elsewhere in this chapter and Chapter 2.

(⋮ refers to infrequent energy levels obtained by a given natural environment) produced by human hand-held percussion. However, from the perspective of fracture mechanics one would still expect a greater proportion of acute angled removals because this constitutes the more easily failed surface. This latter problem becomes clear when considering the surface area available on nodule surfaces compared to the available area of acute-angled edges. If clast on clast impingement is a stochastic phenomenon, then probabilistically, a higher percentage of contacts between clasts will occur on obtuse-angled surfaces. In addition, it would seem reasonable that under conditions of static loading a clast impinging on another's edge would often accommodate the stress by slipping rather than failing.

When considering other fracturing environments where either available energy is greatly reduced (e.g., solifluction, fluvial transport) or the impact is dynamic (e.g., mudflows), quite different results can be expected. In fluvial environments, due to, in most cases, markedly reduced energy, fracturing should be greatly reduced in terms of the size of the flake removals, and controlled to a much greater degree by the angles available on the specimens. If the above reasoning is valid, it should be possible to construct models of alteration environments that predict the expectable kinds of alterations to stone clasts given the amount of available energy and the nature of the impacts. A tentative theoretical construction is presented in Table 1.

Table 1

Predictions of Alterations in Natural Environments

High energy	Static loading

(e.g., pressure of thick overlying beds, glacial transport)

Macro-alterations

1. High angle flake removals
2. Abrupt terminations
3. Wide range of size classes

Micro-alterations

1. Striations
2. Pressure cones
3. Edge and ridge crushing
4. Edge and ridge micro-flaking

Low energy	Static loading

(e.g., cryoturbation, solifluction)

Macro-alterations

1. rare, few obtuse-angle removals

Micro-alterations

1. striations
2. pressure cones
3. edge and ridge crushing
4. edge and ridge micro-flaking, sometimes patterned

Note: These predictions are hypothetical in the sense that they are derived predominantly from empirical observation and theoretical considerations. Much more experimental research is needed before they can be considered truly "predictive".

High energy Dynamic loading

(e.g., mudflows)

Macro-alterations
1. wide range of size classes
2. obtuse and acute-angled removals
3. abrupt terminations

Micro-alterations
1. percussion cones
2. edge and ridge crushing
3. random edge and ridge micro-flaking

Low energy Dynamic loading

(fluvial environments)

Macro-alterations
1. rare, acute when present
2. edge and ridge rounding
3. extensive edge micro-flaking
4. more limited ridge micro-flaking
5. occasional striations

Several authors have advocated or undertaken contextual analyses of putatively early hominid sites in North America. In what was perhaps the most insightful approach to the evaluation of the Calico Hills site to date, Haynes (1973) presented a hypothetical reconstruction of the various transport and weathering processes to which the chert clasts at this site must have been subjected. With the predictions for kinds of alterations expected in these environments, Haynes's outline would constitute a useful point of departure for a meaningful consideration of the role of natural flaking at this potentially important site. Unfortunately, this analysis has yet to be undertaken.

In a more detailed analysis, Reeves (1980) has taken a contextual approach to the determination of flaked cherts in Pleistocene deposits near Medicine Hat, Alberta. In this study the author evaluated potential environments for alteration and sought to observe characteristic attributes of these processes.

F. Absolute Criteria

Absolute criteria for naturally fractured versus humanly fractured clasts can be considered on the population or the specimen level. Barnes's (1939) method was designed as an absolute criterion on the population level.

Absolute criteria for recognizing naturally altered individual specimens are few but important to the overall research design. Recognition of naturally fractured specimens is important in initial population segregation and for the analytic comparison of the natural with the "questionable" population. However, it would be misleading to group all naturally fractured specimens known to have been fractured by different agencies into a single population for statistical analyses, as Taylor and Payen (1978) have done.

There are, unfortunately, very few absolute criteria for recognizing natural flaking. The most common, and easily distinguished natural fracturing process is freeze-thaw fracture. This process produces distinctive attributes that are easily discernible on most lithologies (cf. Pei 1936, Oakley 1972). These attributes consist of 1) concentric rings originating in the center of the spall, 2) presence of nipples at the center of the concentric rings, 3) the absence of features indicative of percussion removal (e.g., platform, bulb of percussion). The attributes are sufficiently distinctive to make it difficult to confuse this natural process with human stoneworking.

Many previous studies of natural flaking at problematic archaeological sites suffer due to the fact that they did not recognize the presence of frost spalls (Duvall and Veneer 1980) or they were mentioned but nonetheless were grouped with the remainder of the collection for analytical purposes (Taylor and Payen 1978).

As discussed in Chapter 2, failure to segregate populations makes subsequent statistical manipulation of the data invalid as the products of non-identical processes are represented. Further, the lack of feedback from the contextual to the technological evaluation makes the latter observations suspect.

The presence of deeply striated ventral surfaces on stone flakes may be considered an absolute criterion for natural flaking in certain contexts. Their presence would imply post-detachment transport in an environment capable of producing deep striations, which in glaciated regions would most probably be due to glacial transport. However, if an archaeological site were subsequently overridden by glacial ice artifacts may be altered. Stapert (1976) describes striated handaxes in tills in the Netherlands.

It may be possible to define absolute criteria for the products of other environments and/or geomorphic processes. At this stage, given the paucity of empirical and experimental research, these criteria are not available.

G. Evaluation of Fracturing Environments

In any evaluation of a natural fracturing envirionment at least three general parameters must be considered: 1) competence of the transport medium, 2) clast motion within the transport medium, and 3) length and/or periodicity of transport (Figure 3). These are merely general parameters, not necessarily linked to any specific geomorphic context. Thus, qualitative assessment of these parameters can be conducted in the absence of detailed geomorphic assessment.

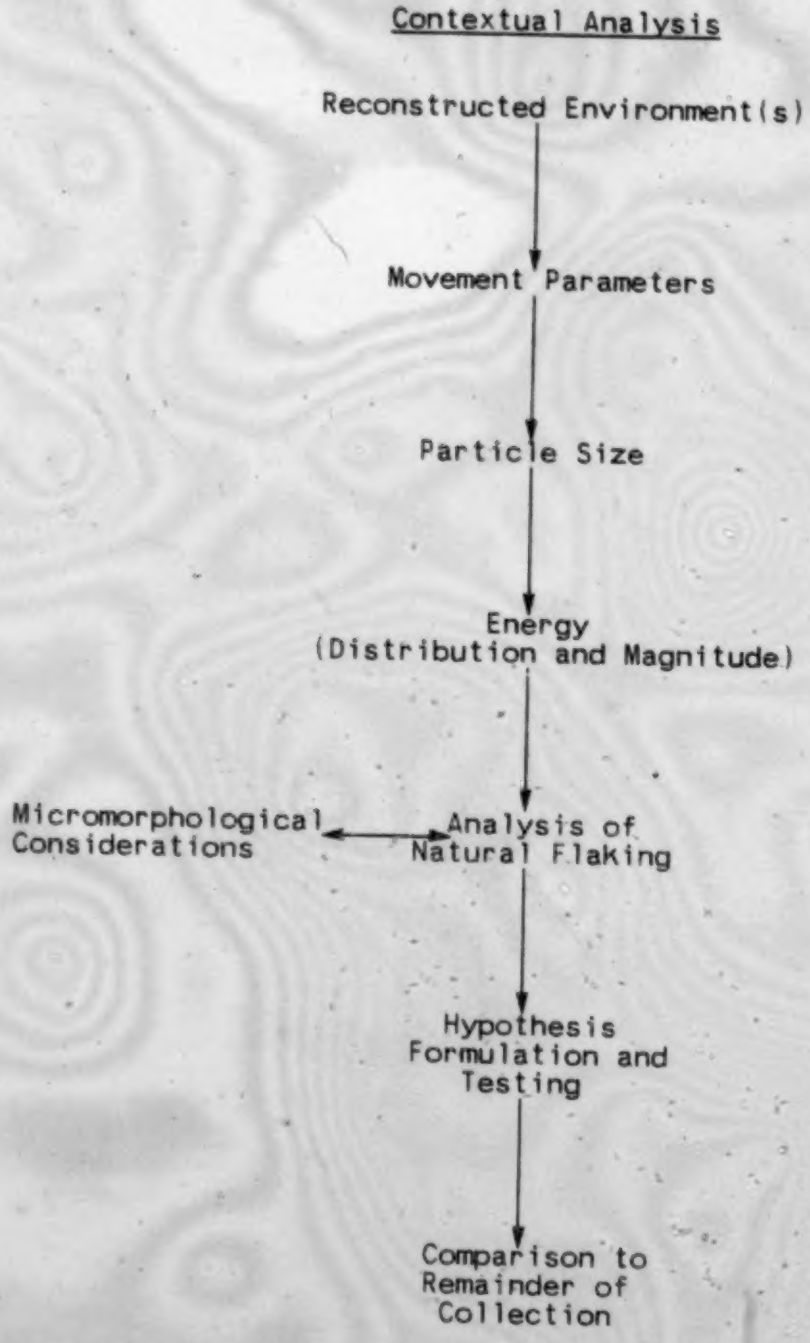
Contextual Analysis
Reconstructed Environment(s)
Movement Parameters
Particle Size
Energy
(Distribution and Magnitude)
Micromorphological Considerations
Analysis of Natural Flaking
Hypothesis Formulation and Testing
Comparison to Remainder of Collection

Figure 3. Research design for contextual analysis

Competence refers to the ability of the transport medium to move objects with sufficient force to produce alterations of a given magnitude. The usage of the term competence is similar though not identical to its definition with respect to sediment transport in fluvial systems. Thus a stream may be competent to transport and produce micropmorphological alterations to a given size range of clast but may not be competent to produce macro-alterations. On the other hand, the potential energy involved in glacial transport (other factors e.g., debris composition, being equal), is sufficient to produce the entire range of micro- to macromorphological alterations. Thus glacial transport is a process competent to produce any reasonable magnitude of alteration to stone clasts.

The difference between stream competence and alteration competence can be illustrated with an example of soil flow on hillslopes. Solifluction, or soil creep are competent to transport a wide range of size classes under the proper conditions of soil moisture content and gravity. However, their competence to produce alterations to stone clasts has been observed to fall primarily in the micromorphological range (Warren 1914, Pei 1936, Stapert 1976). In the case of soil flows, lack of competence to produce macro-alterations is due to the generally low energies involved in clast on clast loading; the energy of the system as a whole is, however, relatively large. This apparent anomaly can be explained by the second related parameter, the movement of clasts.

The movement of clasts within a transport medium is an important, often poorly understood consideration in the evaluation of natural alterations to stone clasts. The following example of clast movement within fluvial systems illustrates the significance of this parameter.

Fluvial Transport

In streams, the size class of particles of interest to the natural fracture question are transported primarily by traction. Pebbles and cobbles are generally too heavy to be saltated upwards through hydrodynamic lift into the zone of increasing velocity near the surface. Instead, where net movement does occur, the energy involved is generally supplied by turbulent velocity leading to minimal sliding and dragging movements along the stream bed (Butzer 1976). Near the bed, current velocity approaches zero (Butzer 1976) and, contrary to common belief, pebbles will be unlikely to roll rapidly along the stream bed.

Although hydrodynamic lift would generally be insufficient to play a role in lifting medium-sized clasts, it does appear to cause vertical vibrations on the order of millimeters or centimeters (Schumm and Stevens 1973). This vertical movement, although minimal, is significant in terms of size reduction of clasts. When brittle solids with sharp acute-angled edges undergo this in-place motion, extensive microflaking of the edge may be expected (see Appendix I).

A further alteration process in stream environments is "wet sand blasting" (Kuenan 1961, Shackley 1972), or the abrasion of clast edges and surface by fine-grained particles carried in suspension or by saltation. Exposed surfaces are continually impacted by fine particles resulting in smoothing of edges and polishing of surfaces.

The latter process is an on-going phenomenon taking place throughout an annual cycle of a stream. The previously discussed processes occur with less frequency and and a non-uniform energy distribution. Turbulent energy increases to a maximum between 1/2 and 3/4 bankfull stage and decreases beyond this point. For the most of the cycle turbulent velocity is probably not great enough to transport the coarser fraction of the bed-load. In addition, maximum turbulent velocity is distributed unevenly accross the lateral and longitudinal stream profile. Alteration competence will then vary spatially and temporally.

H. Discussion

The above theoretical outline generates significant propositions for the investigation of natural flaking in fluvial environments. In most situations streams are not competent to produce significant numbers of macro-alterations. In situations where sufficient energy is present, it will be distributed unevenly through time and space. On the other hand, micromorphological alterations may be produced continuously through time. If the degree of microalteration is quantitatively measured, as suggested by Shackley (1972), then it may be possible to outline a chronology of flake scar production. Variable flake scar ridge width measurements may be suggestive of intermittent flake removals and a natural origin.

It is unlikely that use-wear studies of specimens having undergone significant fluvial transport will be of much utility. Micromorphological alterations from polishing to microflaking of edges occur with sufficient regularity to obscure or alter original human alterations. Unless a great deal more experimental work is undertaken it is unwise and probably misleading to use micromorphological criteria to argue for a human origin for questionable specimens in a fluvial context as, for example, Singer (1978) has done.

To carry out a contextual analysis adequately, first the life history of a collection must be fully reconstructed with respect to the kinds of alteration environments to which specimens were subjected. Their sequencing may also be an essential part of the analysis. Secondly, a thorough contextual analysis requires adequate knowledge of the essential parameters of a given environmental process.

Reconstruction of the life history of a collection of specimens will only rarely be complete. If specimens are far removed from their initial source area, only the most recent environments to which they have been subjected may be discernible. Beyond these latter stages, earlier stages of the life history will be a matter of hypothetical reconstruction.

The second problem is more complex, and unfortunately less easily addressed given the current state of knowledge. Most of the essentials of alterations in particular contexts must be derived from geological and geomorphological literature. It is rare, however, that the observations made by specialists in these fields will be directly relevant to the questions posed by the contextual analysis. Thus, many of the predictions generated by the analysis will be, in part, conjectural. The case studies in following chapters suffer in this regard.

Further information can be derived from the limited experimental and empirical observations carried out by archaeologists. Again, this information suffers due to its limited extent and the fact that most of it was carried out earlier in this century prior to a clear understanding of the mechanics of rock fracture. Additionally, much of this literature is very subjective and only rarely quantified.

I. Technological Analysis

When human beings intentionally alter stone materials, depending upon the mechanical properties of the raw materials, and the desired end-product, they employ a limited set of production techniques. These procedures leave characteristic attributes that can be objectively observed and/or measured. This is not to say that these attributes are by any means mutually exclusive to human stone alteration. It is to be expected that natural processes will, in some instances, produce features that will mimic such attributes of human stoneworking as platform preparation or dorsal surface flake scars. However, it is assumed that these features will not characterize the majority of natural flakes or altered nodules.

Attributes of human stoneworking can be objectively recorded on populations of specimens. However, few of these are *diagnostic* of human alteration other than in a probabilistic sense (depending upon the numbers, sizes, and patterning). The step from data collection to evaluation involves an intermediate step of comparison between other populations. These populations can be either naturally altered specimens from the site deposits, or data from known human stoneworking products collected elsewhere.

The outline of attributes below focuses on two generalized human stoneworking strategies: percussion flaking and bipolar flaking. These strategies were selected primarily because of their relevance for the case studies to follow. In addition, simple flakes and minimally-flaked stone objects form the bulk of specimens in the questionable sites discussed earlier.

Proximal Attributes

Observation of proximal end attributes is extremely important because a number of behavioral processes such as platform preparation (grinding, faceting) and platform isolation may be recorded on specimens. In addition, patterned striking platform geometry (depth, width, shape) may be useful for distinguishing hominid stoneworking from natural flake removals.

Platform Remnant Depth

This is a continuous level measurement of the distance of the widest part of the striking platform from the ventral to the dorsal face (figure 4). The depth of the platform remnant is dependent upon the distance of the PFA (point of force application) from the core edge (Phagan 1976: 44). Deeper platforms on human flakes may indicate a desire to obtain larger flakes in the early stages of core reduction. However, the same result can be obtained by isolating and preparing a suitable platform for flake removal. Human stone flaking can then be predicted to vary considerably in values for this attribute. If, however, platform remnant depths are characteristically shallow in relation to overall flake dimensions, then a case for a human origin may be indicated.

Platform Remnant Width

Platform remnant width is the maximum width of the striking platform between the two lateral edges. Similar to platform remnant depth, this measurement correlates negatively with the degree of platform preparation and isolation.

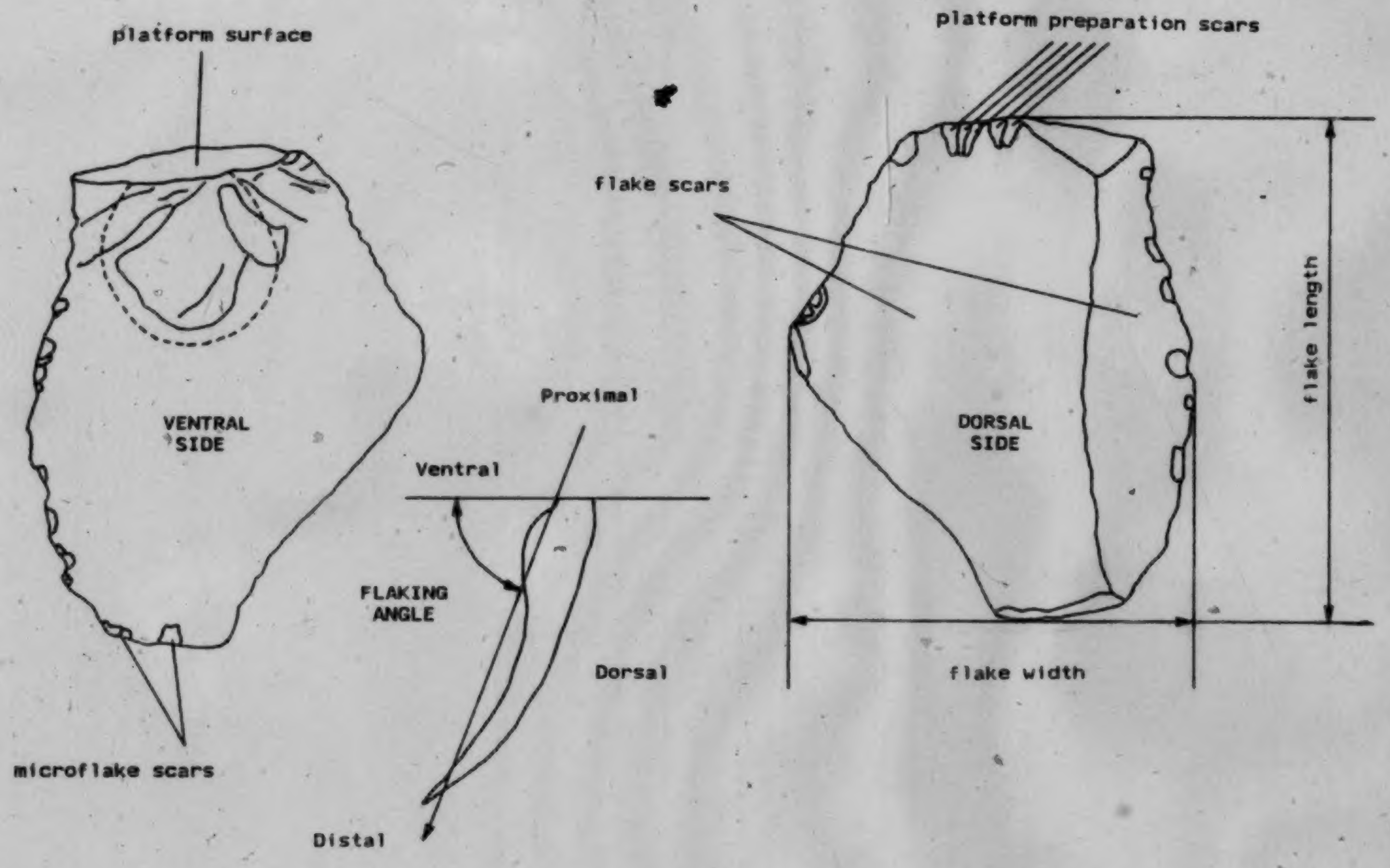
platform surface
VENTRAL SIDE
microflake scars
Proximal
Ventral
FLAKING ANGLE
Dorsal
Distal
platform preparation scars
flake scars
DORSAL SIDE
flake length
flake width

Figure 4. Flake attributes used in this study.

Platform Remnant Surface

This nominal attribute records the kind and degree of alteration of the platform surface prior to flake removal (for definitions see Phagan 1976: 46-47). Platforms may retain the original surface of the parent nodule (e.g., cortex), facets or a ground surface. In a very active, high energy natural fracturing environment it is quite possible that a low number of platform remnant flakes will exhibit faceted platforms. However, where the majority of surfaces are non-cortical a human origin can be strongly inferred (Patterson n.d.). On the other hand, the presence of predominantly cortical surfaces does not automatically preclude a human origin. Initial stages of core reduction such as quarrying activites may result in predominantly cortical platform surfaces (Phagan 1976: 47).

Platform Preparation Scars

This attribute records the presence of microflake scars emanating from the dorsal edge of the the platform remnant (for definitions see Phagan 1976: 49). In hominid stoneworking platform, preparation serves to remove overhangs on the core face thus "strengthening" the edge as well as to isolate the platform. In either a natural percussive or pressure environment these features would not be out of place (see Chapter 4). It should be noted that platform preparation scars are often absent on humanly-struck flakes as well.

Platform Angle

This attribute is similar to that recorded by Wilmsen (1970: 14-17), Phagan (1976: 47-48), and Bleed (1976). The platform angle recorded here is the complement of the actual angle between the platform surface and the ventral flake surface. As suggested by Bleed (1977) and Phagan (1976) this measurement is preferable to the actual angle as it gives a comparable figure to that taken off core faces such as Barnes's (1939) angles-platform scar measurement.

The platform angle is determined primarily by the angle of applied force (Phagan 1976: 49). The angle of applied force is manipulated to control flake length. Contrary to Patterson (n.d.), human beings do occasionally produce flakes with platform angles greater than 90 degrees. Rather, steeper platform angles reflect more outward directed force components (Phagan 1976).

Distal End Attributes

Flake Termination

Flake terminations are recorded in nominal states. Two of these states are right-angled terminations (step and hinge terminations). These two states may indicate inadequte force amounts and/or very high outward components in the angle of delivery (Phagan 1976: 51). Also, right angle terminations occur with great regularity when the core face is very steep and/or obtuse. However, in this instance, flake removal will only proceed with very high force components.

Ventral Surface Attributes

Attributes of ventral surface morphology are, for this study, only recorded as being present or absent. The value of these attributes, including ripple marks, hackles, eraillures, and percussion bulbs (for definitions see Bonnichsen 1977) is primarily for distinguishing percussive from pressure flake removal.

Dorsal Surface Attributes

Cortex

This attribute approximates the percentage of unmodified area remaining on the dorsal surface. It may be difficult to determine non-cortical from cortical surface for some lithologies, and/or those specimens that have been subjected to a lengthy period of weathering.

Scar Number

This attribute quantifies the number of individual flake scars present on the dorsal surface. As in the preceding cortex attribute, the number of dorsal scars present on a specimen indicates the degree of prior modification the parent nodule underwent prior to flake removal. It may prove difficult to distinguish thermal spalls from flake scars on some coarse-grained materials that are not conducive to the formation of ventral surface attributes.

Scar Size and Orientation

Because of the difficulty in recording the attributes of scar size and orientation objectively these attributes were only subjectively assessed in this study. However, where great regularity in size and orientation of dorsal flake scars exists, a human origin is strongly implied.

Production Technology for Quartzite Cobbles

In many areas of the New World, particularly in the northern plains region, the most common raw material for stone tool production consists of rounded quartzite cobbles. These clasts are generally characterized by a hard, smooth, siliceous cortical surface encasing a matrix of cemented quartz grains with considerable variation in the degree of cementation and coarseness of the grains.

Many of the production attributes outlined previously are applicable to this raw material, since it was also bifacially and unifacially flaked by aboriginal peoples. However, due to the granular structure of most quartzites, it may be difficult to observe many of the attributes on most specimens. In addition, due to the characteristics of the cortical surface and the degree of rounding of edges (i.e., few naturally occurring sharp, acute-angled edges), more specialized techniques of core reduction were commonly employed with this raw material.

Aboriginal peoples utilizing quartzite cobbles for stone tool production commonly split cores longitudinally or into a series of fragments by means of radial fracture techniques (throwing clasts against clast) prior to hand-held percussion flaking (Honea 1965, Bonnichsen and Young n.d.). Failure by radial fracture can occur when high velocity impacts to cores with oval to circular cross-sections are made with a hammerstone with a semi-circular end (Bonnichsen and Young n.d.:170). The end product of failure by radial fracture may be two longitudinal sections of the original clast (or fragments thereof) if the specimen is oval cross-sectioned or, when the specimen has a circular cross-section, the clast may fail into several "orange-section" fragments (Bonnichsen 1977: 125).

Commonly aboriginal peoples attempted to fail clasts with oval cross-sections by placing one end of the longitudinal axis atop an anvil and delivering a high velocity impact with a thrown hammerstone. These end-products, with the hard cortex removed from portions of the specimen were then more easily flaked by hand-held percussion techniques.

J. Assessment

Following evaluation of contextual and technological parameters it is possible to make probabilistic assessments regarding the natural or human status of a population of specimens. Assessment may cover the entire assemblage (see Chapter 6), or consider portions of the assemblage separately (see Chapter 5) where specimens can be subdivided into smaller analytical populations. Assessment of micro- versus macromorphological alterations must be considered separately.

Assessment is, to a certain degree, subjective. However, the procedures and the criteria leading to the assessment can be explicitly stated. Other scholars are then free to evaluate the conclusion on the basis of objective criteria. Conclusions can be strengthened or altered on the basis of additional evidence. In this way discussions about questionable sites can be additive and dialectic rather than simply argumentative.

No clearcut quidelines for assessment can be laid out at this time. In the absence of absolute criteria and objective principles for estimating confidence limits, assessment consists of posing four general questions:

1) What criteria argue for a natural origin, and 2) what criteria argue for a human origin. 3) What criteria argue against a natural origin, and 4) what criteria argue against a human origin.

The first question involves evaluating whether or not the population, or specimens within the population, are in conformity with the predictions derived from the contextual analysis. This evaluation may be inconclusive when sample size is small, or the reconstructed environments are poorly understood in terms of relevant parameters (see Chapter 6).

Alternatively, the evaluation may be strengthened by comparison with known naturally fractured specimens (see Chapters 4 and 5).

The second question may be addressed with somewhat greater confidence. Considerable comparative data has been published and considerable research has been conducted with respect to fracture mechanics of human stoneworking.

The third question involves evaluating whether specimens are anomalous in their contextual parameters. Again, estimation of confidence limits is subjective. However, where one or more environments have been reconstructed it may be possible to eliminate one or more of them from consideration (see Chapter 4).

The fourth question is also difficult to address. Arguments against a human origin consist primarily of stressing minimal alterations to specimens. However, in certain behavioral contexts (e.g., quarry activity), human alterations may in fact be minimal.

A certain amount of "artistry" is required in the assessment of questionable site assemblages, and the selection of alternative hypotheses will rarely be straightforward. However, if the range of possibilities can be narrowed and criteria for assessment explicitly stated it would be a major advance over current approaches employed in the assessment of questionable sites.

IV. The Timlin Site:Fluvial and Glacial Attritional Processes

A. Introduction

The flaked stone specimens from the Timlin site, east-central New York state, present an extremely complex interpretive problem. The context of the specimens in coarse, poorly-sorted gravels has led several authors to question the artificial status of the proposed artifacts (cf. Funk 1977, Cole and Godfrey 1977). Further, the geomorphic context, in coarse fluvial gravels, admits to the strong possiblity for extensive micromorphological alteration to specimens. As a final complicating factor, the relative contemporaneity of specimens is difficult if not impossible to determine in this situation; and given the potential of fluvial systems to select and transport clasts of different size and shapes, the possibility for sample bias is large.

The assemblage of proposed humanly-flaked stone specimens consists primarily of flakes, many of which exhibit unifacial edge damage, and several cores or core fragments. The specimens occur in postglacial fluvial gravels, the clasts of which are ultimately derived from glacial/glacio-fluvial deposits in the immediate area (Fleisher 1980). The lithological composition of the assemblage corresponds in kind to the lithologies of brittle clasts present in local fluvial and glacial deposits (i.e.

no exotic materials). Given this situation, alternative hypotheses for the origin and alteration of the specimens from this site in fluvial or glacial contexts must be objectively assessed.

B. Background to the Problem

Several archaeologists (cf. Ritchie and Funk 1969, Funk 1977; Starna 1977, Cole and Godfrey 1977) have questioned the artifactual status of flaked stone specimens described in a series of articles by Raemsch and others (cf. Raemsch and Vernon 1977a; Raemsch 1977b; Stagg, et al. 1980). In the initial descriptions of the site, the flaked stone materials were believed to lie within coarse stony tills and on weathering surfaces separating tills of different ages (Raemsch and Vernon 1977a). Because of the context of the specimens, their visible weathering, and their technological simplicity, various New York archaeologists suggested that fracturing during glacial transport might be an equally valid alternative hypothesis for their origin.

In addition to the hypothesis of flaking during glacial transport, the position of the specimens within coarse, fluvial gravels hinted strongly at the possibility of alteration through vigorous fluvial transport. The shiny, polished appearance of the cortical surfaces of the specimens and the degree of rounding of edges lent further support to this hypothesis. In particular, it was felt that the nibbled edges of many specimens might have resulted from transport by this mechanism.

Ritchie and Funk (1969) were quite adamant in their assessment of examples of proposed human flaking at the Timlin site. In their opinion, the specimens were,

> "...unequivocally not the work of man, but the product of natural agencies, of erosion by rolling, battering, and scouring and other forms of attrition. Such flakes as have been removed are purely random and show none of the characteristics resulting from human workmanship (p. 15)".

and

> "Most of the items from the site...cannot be called artifacts by any exercise of the imagination (Funk 1977: 543)".

and

> "With very few exceptions, these 'artifacts' were simply rocks , or, technically geofacts (Starna 1977: 543)".

Two primary reasons for not accepting the specimens as resulting from human activity were given;

1. Lack of lithological diversity (Cole and Godfrey 1977): the specimens comprise two primary lithologies, both of which are abundant in the gravels at the site and in surrounding glacial and fluvial deposits.

2. The site, being quite near the source area for the lithologies present in the collection, would be expected to contain large numbers of sharp, glacially-fractured specimens in a fairly fresh state, allowing for their misidentification as artifacts (Cole and Godfrey 1977).

In order to resolve the disputed status of the specimens, several authors (Cole and Godfrey 1977, Funk 1977) advocated use of the Barnes method as an objective technique for evaluating the conflicting opinions. In a reply to criticisms leveled at the Timlin site, Raemsch (1977) addressed the issue of Barnes's angles platform-scar measurement by providing a very rough assessment of the distribution of values for this variable on specimens in the collection. Although the angles of flakes and flake scars were, in Raemsch's opinion, obtuse, he argued that this result is not unexpected in certain human industries, for example the Clactonian.

Before discussing more recent criticisms of the Timlin site, a number of comments regarding the use of the Barnes method are appropriate. As originally defined (Barnes 1939: 109-111) the angles platform-scar was to be measured on specimens exhibiting flake scars greater than 1 cm in length and exhibiting their point of initiation. Barnes made no mention of measuring the flaking angle on flakes. In the Timlin collection, the vast majority of specimens are flakes exhibiting few flake scars on cores or flaked artifacts of the appropriate length for the application of this test. Thus, the Barnes method, per se, would be inappropriate for the Timlin collection.

However, if one were to measure the flaking angle or Wilmsen's (1970) Beta angle on flakes, as Bleed (1977) has done for the Sozudai collection, it would be necessary to take the complementary angle to that read directly on the recording device. This measurement is then comparable to the angle measured on cores or flaked artifacts. If this procedure is not followed, the vast majority of flakes, from any site (including Timlin or Late Woodland sites) will exhibit a majority of obtuse-angled specimens.

C. Geomorphic and Geologic Context

Specimens collected from Locus 1C at the Timlin site were recovered from poorly sorted fluvial gravels from the highest fluvial terrace (T2) (Figure 5). These gravels, occasionally interbedded with coarse sandy lenses, "rest directly upon till forming a contact characterized by large lag boulders (up to 2 feet in diameter) and cut and fill channels within the till" (Fleisher 1980: 6). The western portion of the terrace is bounded by a fluvially sculptured morainal terrace, the contents of which probably supplied most of the material that was later reworked to form the fluvial gravels of the site. Fleisher (1980: 10) interprets the degree of sorting and cut and fill structures to indicate "limited distance of transport and rapid deposition in swift currents" of materials making up the gravel stratum.

The coarseness and angularity of the fluvial gravels at the Timlin site give a false impression of the competence of West Creek to transport the relatively large chert and siltstone nodules in the deposits. Funk (1980: personal communication) observed large chert boulders with faceted surfaces in the modern creek bed and felt that this faceting resulted from tumbling and bashing of one nodule against

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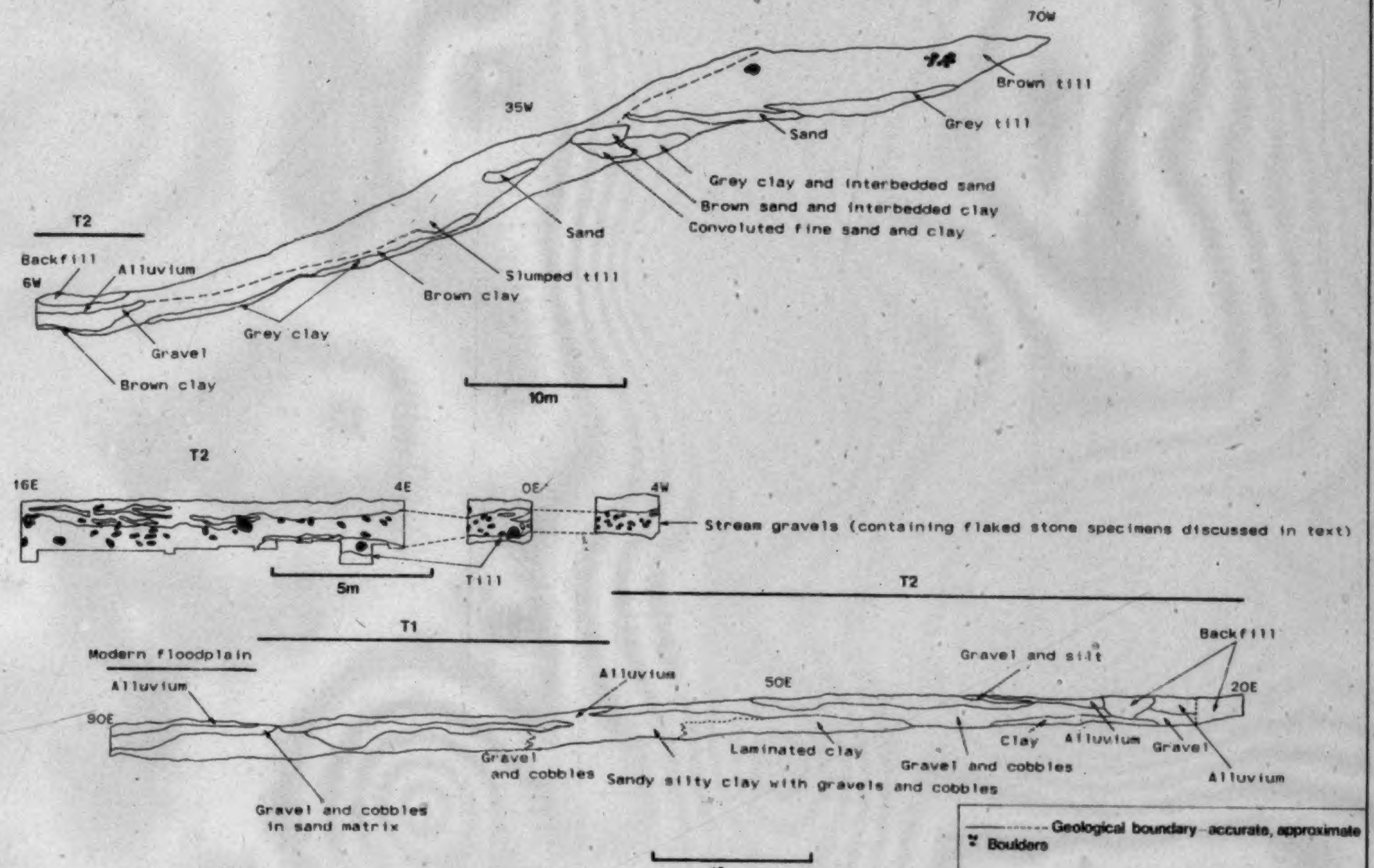

70W
Brown till
Grey till
Sand
35W
Grey clay and interbedded sand
Brown sand and interbedded clay
Convoluted fine sand and clay
Sand
T2
Backfill
6W
Alluvium
Slumped till
Brown clay
Grey clay
Gravel
Brown clay
10m
T2
16E
4E
0E
4W
Stream gravels (containing flaked stone specimens discussed in text)
5m
Till
T2
T1
Modern floodplain
Backfill
Gravel and silt
Alluvium
50E
20E
Alluvium
90E
Clay
Alluvium
Gravel
Laminated clay
Gravel
and cobbles
Gravel and cobbles
Alluvium
Sandy silty clay with gravels and cobbles
Gravel and cobbles
in sand matrix
10m
Geological boundary - accurate, approximate
Boulders

Figure 5. Timlin site profiles.

another. However, it must be borne in mind that the composition of the West Creek gravels is more a function of the proximity of the glacial sediments the stream is currently reworking. In this case the stream is transporting those sediments it is competent to move (primarily suspended and dissolved load) thus winnowing out the finer matrix from the coarser clasts which probably do not undergo significant transport.

A general alteration model for chert and siliceous siltstone clasts eventually deposited at the Timlin site is presented in Figure 6. Reconstructed geomorphic environments are on the left side of the figure involving outcrop disaggregation, glacial, and finally fluvial transport. Alteration processes and products are on the middle and right side of the figure.

Flaking by Glacial Transport

The observation of clast abrasion in present glacial systems, or the imitation of these processes by experiment is, for practical reasons, difficult. What literature does exist regarding clast attrition by glacial transport comes primarily through deposits derived from this process(cf. Drake 1972). These studies are somewhat inadequate for the purposes of this study as they simply represent reconstructions of proposed mechanisms of attrition: and the lithologies studied are rarely the isomorphic, brittle solids sought after by hominid stoneworkers. Nevertheless, it is possible to examine several dominant modes of glacial

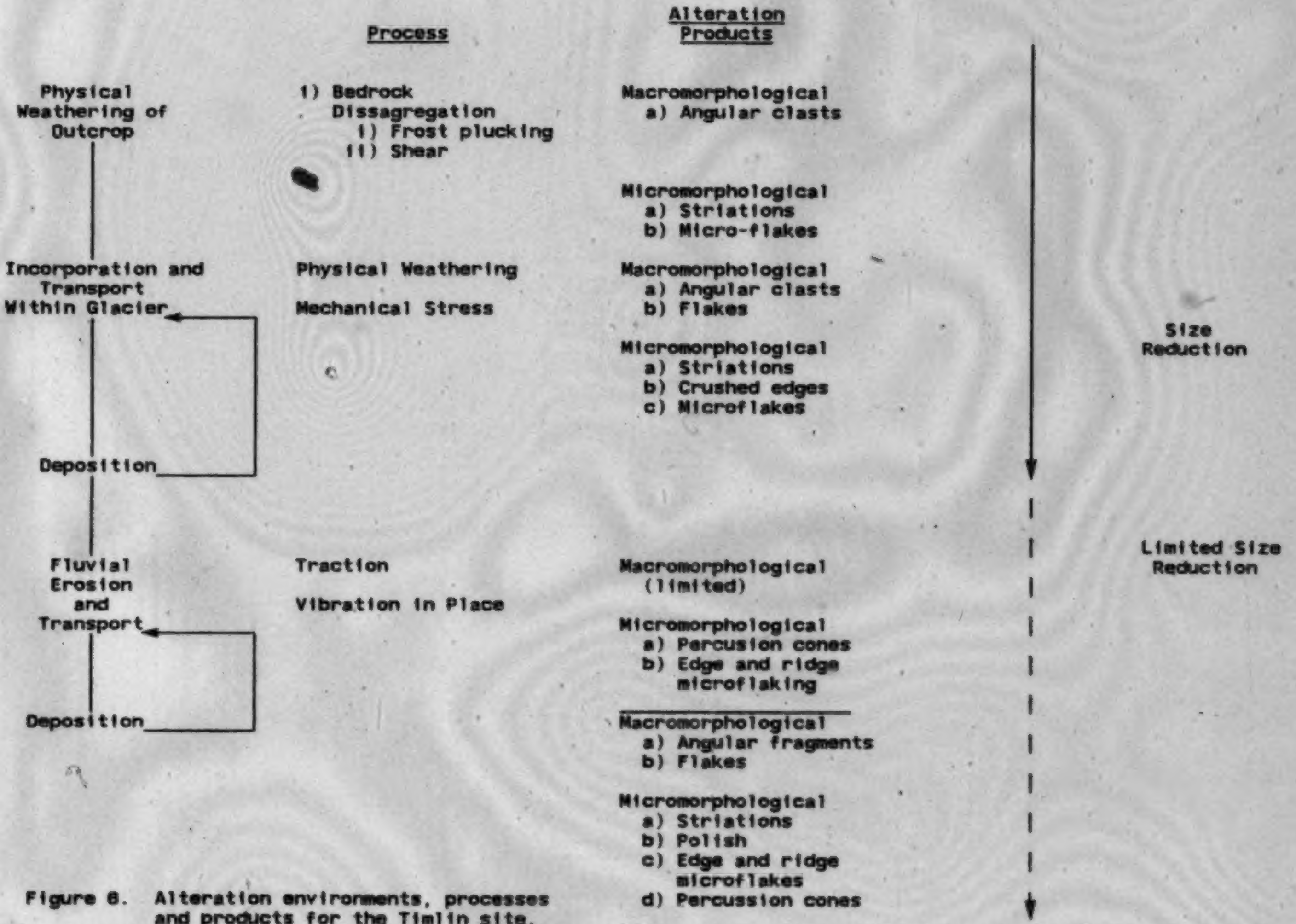

Process
Alteration Products
Physical Weathering of Outcrop
1) Bedrock Dissagregation
i) Frost plucking
ii) Shear
Macromorphological
a) Angular clasts
Micromorphological
a) Striations
b) Micro-flakes
Incorporation and Transport Within Glacier
Physical Weathering
Mechanical Stress
Macromorphological
a) Angular clasts
b) Flakes
Micromorphological
a) Striations
b) Crushed edges
c) Microflakes
Size Reduction
Deposition
Fluvial Erosion and Transport
Traction
Vibration in Place
Macromorphological (limited)
Micromorphological
a) Percusion cones
b) Edge and ridge microflaking
Limited Size Reduction
Deposition
Macromorphological
a) Angular fragments
b) Flakes
Micromorphological
a) Striations
b) Polish
c) Edge and ridge microflakes
d) Percussion cones

Figure 8. Alteration environments, processes and products for the Timlin site.

transport and their role as attritional agents.

The two primary attritional mechanisms involved in the size reduction of clasts in basal till are crushing and abrasion (Drake 1972). Mechanical abrasion is brought about by the frictional wear of clast against clast as well as the movement of clasts through a medium rich in sand-sized particles. Clast crushing is achieved through the point-loading of one or more clasts against another and failure of one or more specimens under sufficient compressive and confining pressure.

In most respects, then, the environment of attrition at the base of a glacier corresponds to Model 1, in which impact areas are largely independent of size and shape, and stress is locally well above the failure point of the included clasts. Assumptions of sufficient confining pressures are difficult to evaluate because frictional forces at the base of temperate glaciers create a semi-aqueous environment in which limited mobility is possible. In addition, in the majority of cases, failure of a specimen is confined to the extreme edge, resulting in crushed and abraded edges of clasts.

The predictions for flaking of brittle solids following the high-energy model are 1) a high proportion of steep to obtuse angled removals, 2) a high proportion of stepped and hinged terminations, particularly on the larger flakes, and 3) location of at least a small percentage of flake removals from free surfaces and ridges as opposed to edges.

In addition, a horizontal vector is supplied in the sub-glacial environment. This movement creates additional micromorphological features such as striations or scratches and pressure cones. Obviously, where these features overrun flake scars, or the ventral surface of flakes, a glacial origin for the flake or a flake scar may be inferred. It must be recalled, however, that not all specimens transported by the glacier will necessarily be striated. In addition, other mechanisms of transport (e.g., fluvial) have been been shown to produce striated surfaces (Judson and Barks 1961).

Fluvial Transport

The downstream size reduction of stone clasts through fluvial transport has long been of major concern to geologists, and an impressive array of published literature exists on the subject. However, much of this literature is not relevant for this study since it deals primarily with the end-products of abrasive and attritional processes, by which time microflaking features have been erased through the rounding of edges. Nonetheless, a certain amount of observational and experimental literature does exist that is useful for designing models of particle movement and attrition in these environments.

Virtually no evidence exists, either experimental or empirical, on which to base an evaluation of macro-alterations in fluvial environments. Because of the lack of data, most evaluations, by neccesity, are of a negative nature (i.e., because it hasn't been observed it must not occur with great regularity).

In the opinion of many early researchers interested in the 'eolithic' problem (Pei 1936, Breuil 1959, Warren 1914), the majority of alteration by fluvial transport was limited to various micromorphological alterations. Clark (1958), in his study of naturally fractured clasts from the Batoka Gorge (Rhodesia), was able to conclude with confidence that fractured clasts in the river-bed were caused by falling from great heights, rather than riverine transport. From his study, he was led to the conclusion that "it is hard to understand how water action could itself remove even average-sized flakes *with any consistency*, though secondary nibbling or 'trimming' is certainly being produced in this way *once there is a sharp edge for the river to work on* (Clark 1958: 70).

Carter (1967) has long been interested in the role of moving water in the fracture of rocks with special reference to claims of natural fracture at the Texas Street site. Through survey of the fluvial transport literature (cf. Kuenan 1956) and by personal observation, he would conclude that fluvial action is not a viable alternative explanation for concentrations of flakes and flaked stone in even coarse fluvial gravels:

> It seems safe to conclude that flaking of stone does not normally occur by stream action, and that the rare instances are due to coincidence of extreme energy situations such as waterfalls coinciding with a weak or very brittle rock (Carter 1975: 14).

My own observations on macro-alterations to stone clasts in streams are reported in Appendix I. Extrapolation of results from the Savage River study are difficult because of differences in stream velocity and other variables. However, the study generally supports the ideas expressed by Carter and Clark regarding the low frequency and magnitude of fracturing in streams (if the qualifications regarding the study are valid).

D. Excavation Procedures

Dr. Bruce Raemsch had conducted excavations of large areas of Timlin Locus 1-C (Figure 7) during three field seasons. Throughout these previous excavations only those specimens were saved which appeared to be the result of human manufacture. During subsequent excavations under the direction of Alan Bryan and Ruth Gruhn from the University of Alberta all siliceous siltstone or chert clasts were recovered and saved in level bags for comparative purposes. Throughout all field seasons, excavation was with rock hammer and trowel. Due to the high clay content of the matrix, dry screening procedures were not carried out. However, during the 1980 field season, portions of excavation units were wet-screened through window screen in order to obtain a sample of smaller sized clasts and/or artifacts.

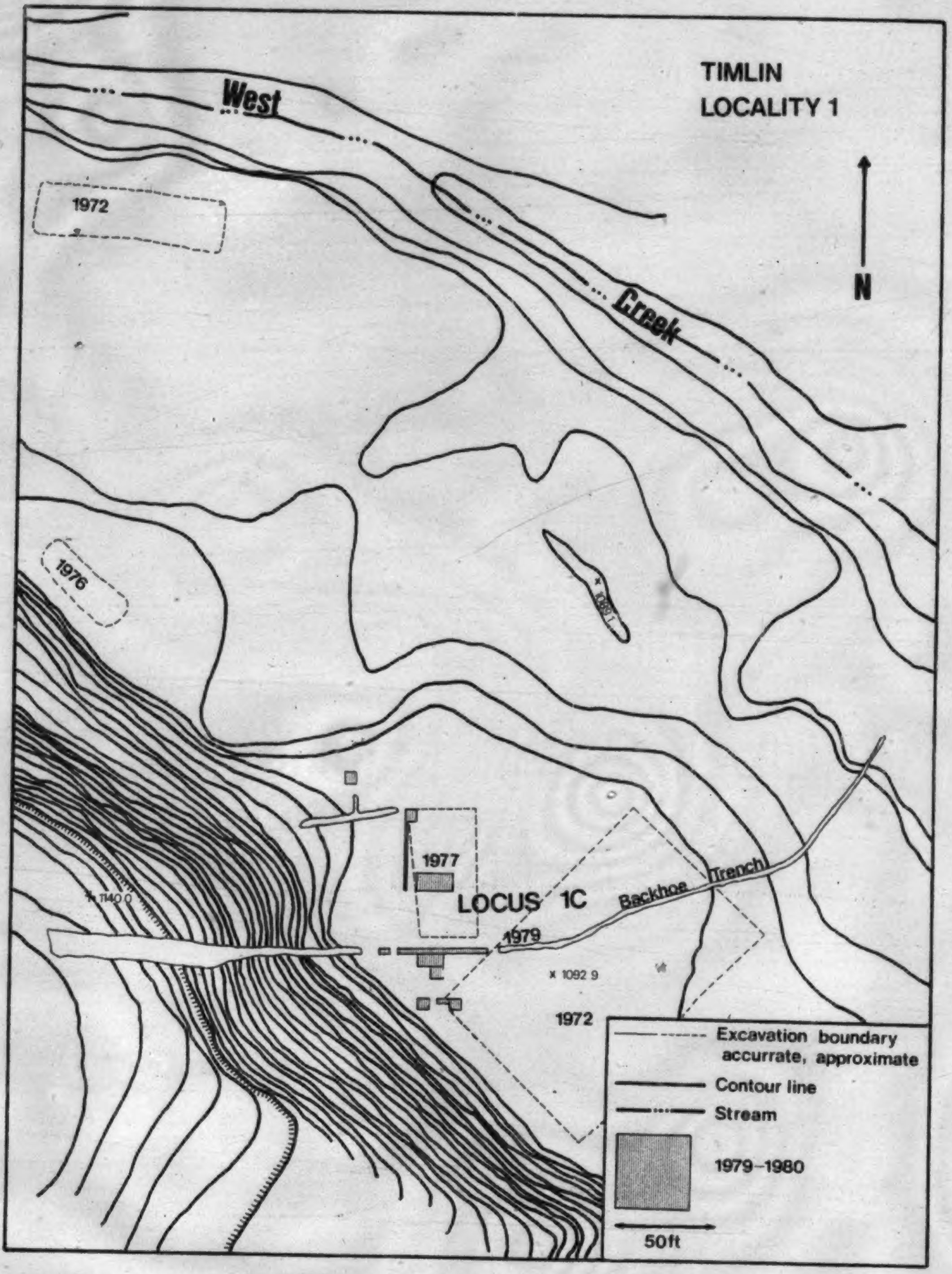

TIMLIN
LOCALITY 1
N
West
Creek
1972
1976
x 1089.1
1977
LOCUS 1C
Backhoe Trench
1979
x 1140.0
x 1092.9
1972
Excavation boundary accurrate, approximate
Contour line
Stream
1979-1980
50ft

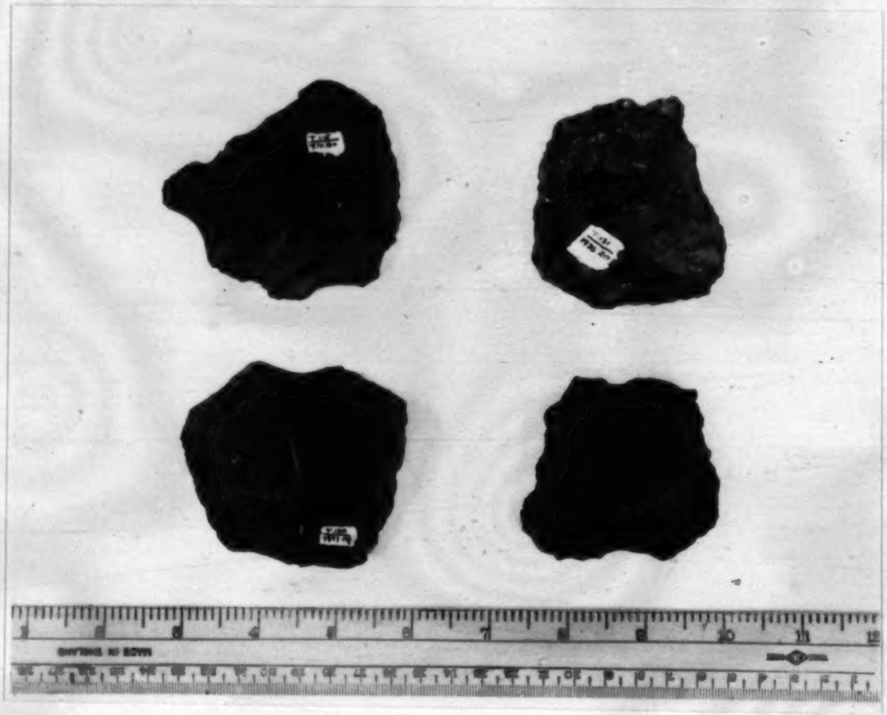
Figure 7. Timlin site map.

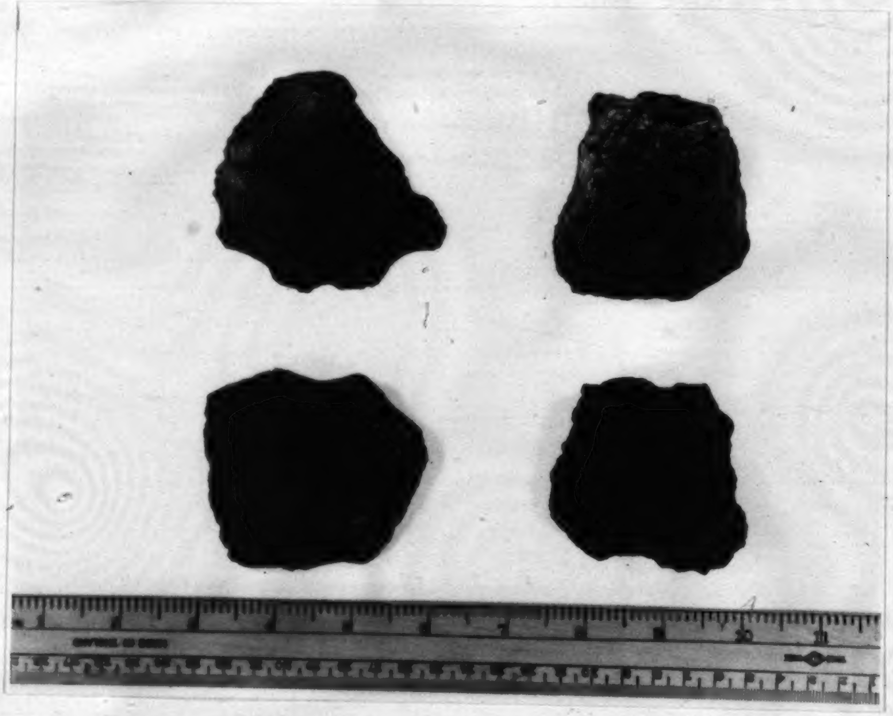
E. Description of Specimens

Those specimens from the Timlin site of possible artificial status consist of chert and silicified siltstone flakes, two bifaces, and five cores and/or core fragments. In addition, a number of possible flake fragments were recovered. Flakes consist of those specimens exhibiting striking platforms and bulbs of percussion (Plate 1): and also including, on some specimens, ripple marks, hackles, and erailures. Distal flake fragments are primarily recognized by the presence of ripple marks, ribs, and hackles. Cores and core fragments consist of those specimens lacking flake features and exhibiting a number of acute angled flake scars on their dorsal surface (Figure 8).

The tentatively identified artifact assemblage contrasts markedly with numerous other chert and siliceous siltstone specimens in the terrace gravels because natural specimens lack flake features and seldom exhibit evidence of more than one flake removal. Pseudo-cores (natural clasts with flake scars) possess very rounded and/or heavily abraded edges and the flake removals have not resulted in shaping of the specimen (Plate 2). Finally, several of these specimens exhibit striations overrunning the flake scar surface. Definite glacially derived flakes were initially identified on the basis of the presence of parallel striations on their ventral surface. A total of nine flakes were identified in this manner as being produced through glacial transport (Plate 3). However, it was predicted that

Plate 1. Flakes from the Timlin site.





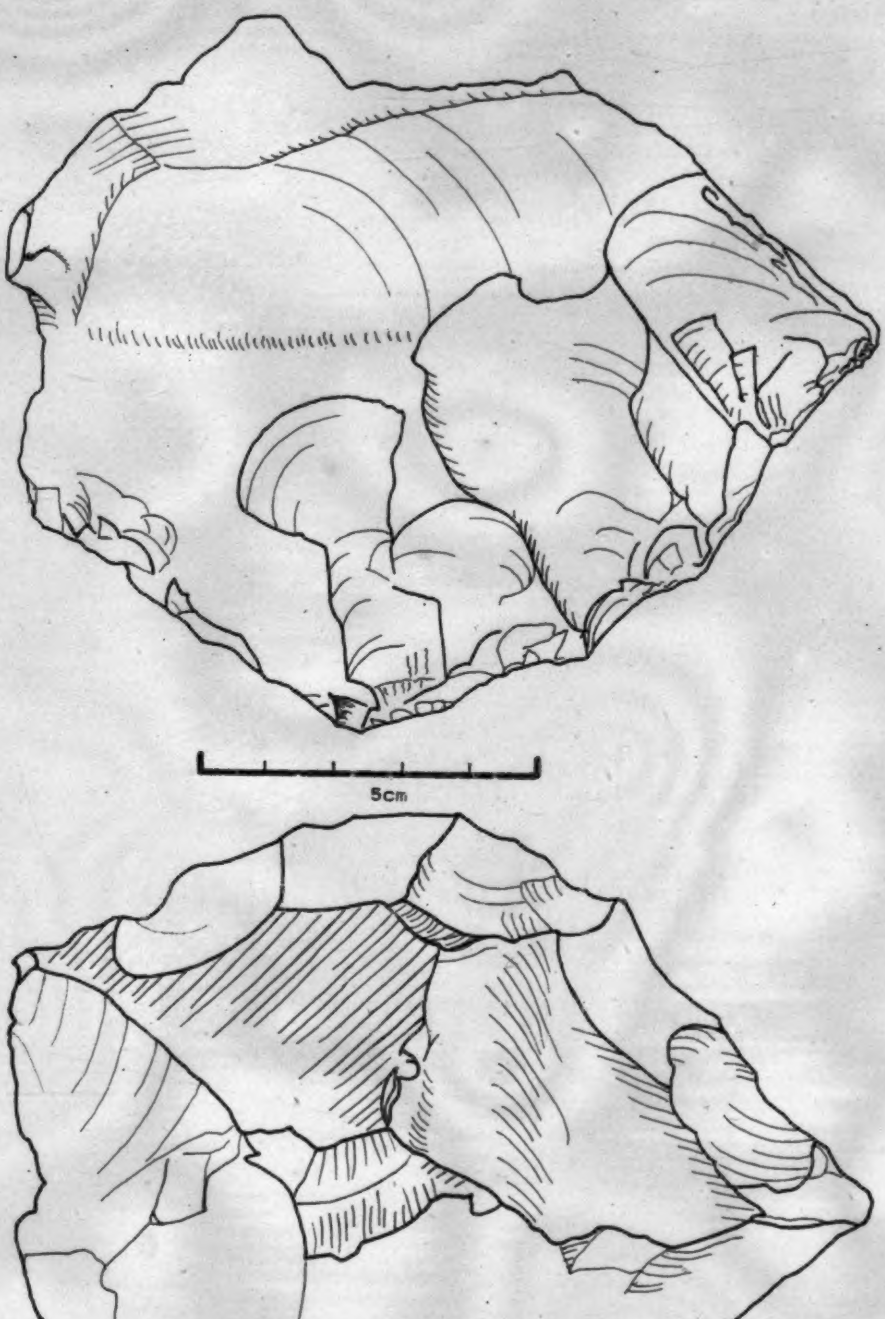
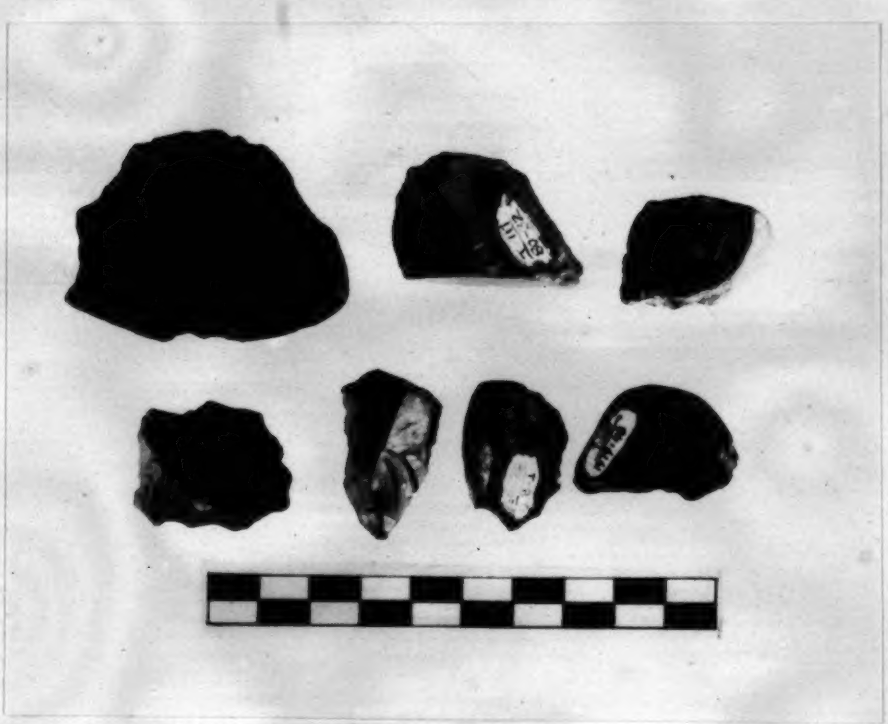
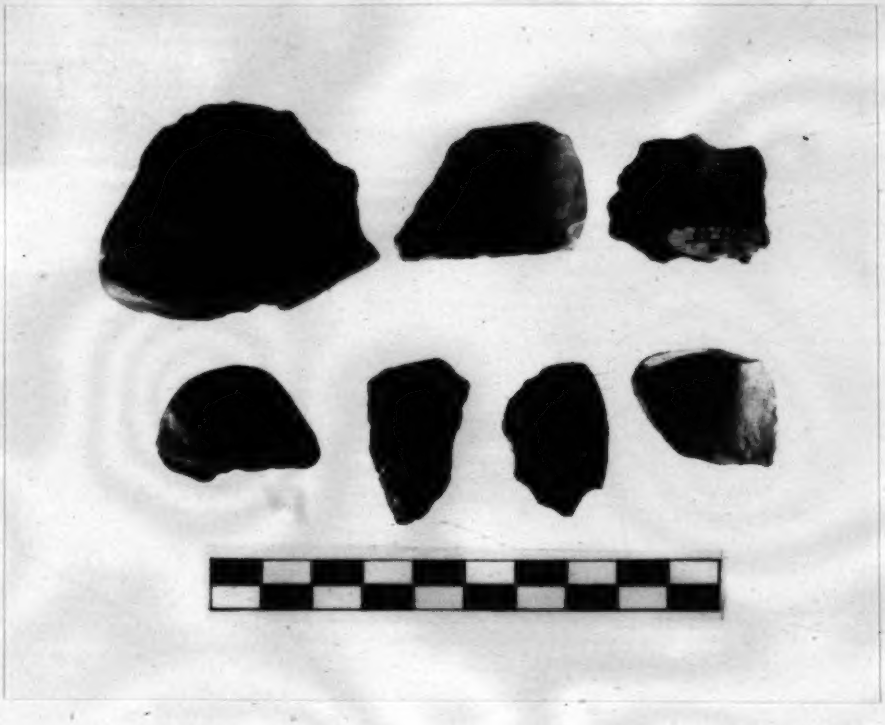


Figure 8. Core from the Timlin site.

Plate 2. Pseudo-cores from the Timlin site.

Plate 3. Natural flakes from the Timlin site.





some glacially derived flakes would go unrecognized due to the lack of striations on their ventral surfaces.

Observations on Edge and Surface Alterations

Several forms of surficial alteration occur on the dorsal and ventral surfaces of the tentative artificial specimens. These alterations include patinas, striations, edge and ridge rounding, and flaking and crushing of ridges and edges.

All siliceous siltstone specimens, either cultural or natural, exhibit a brown patina which is, in some cases, "polished" to a high gloss. The formation of the brown patina from a blueish unweathered core, is clearly a chemical phenomenon, involving the oxidation of ferric compounds forming part of the mineralogical makeup of this lithology (Rottlander, 1975). For reasons that are unclear at present, there exists considerable variability in the degree of patination both between specimens and on altered and unaltered surfaces of the same specimens. Variability between specimens is most likely due to differences in the amount of iron compounds present. Differences in degree of patination on individual specimens is more difficult to evaluate, but probably results from differential exposure to the elements. In some cases, patinated flaked surfaces are somewhat darker than the more intensely weathered cortical surfaces.

The mechanism involved in the polishing of the surfaces of some specimens is also difficult to determine, but it is exceedingly relevant to proper interpretation of the history of specimens. Two processes, wet sand-blasting and/or chemical solution weathering, are likely causes of this phenomenon. If it can be demonstrated that the glossy surface of some specimens is due to fluvial transport, then differential polishing could result from variable lengths of exposure to moving water. If, on the other hand, the gloss is due to solution and precipitation of silica in cavities, then differential weathering might be due to longer time of burial.

Striations are present on the majority of siliceous siltstone level bag specimens, and on many cortical surfaces of flakes (e.g., Figure 9). The chert specimens, on the other hand, exhibit striated surfaces in only a very few instances. Clearly, this fact results from the greater hardness of the cherts; and, whereas cherts are capable of striating the "softer" siltstones, they themselves are more resistant. Glacial striations on the level bag specimens and flake cortical surfaces are significant because their preservation argues against a lengthy exposure to fluvial attritional processes. If the clasts had been exposed for very long period to wet sand-blasting, most of the striations would no longer be visible.

Edge and ridge wear consists primarily of rounding, microflaking, and crushing. Crushing is restricted to ridges of flakes. Rounding of ridges and edges is variable in distribution on different specimens. The same interpretive

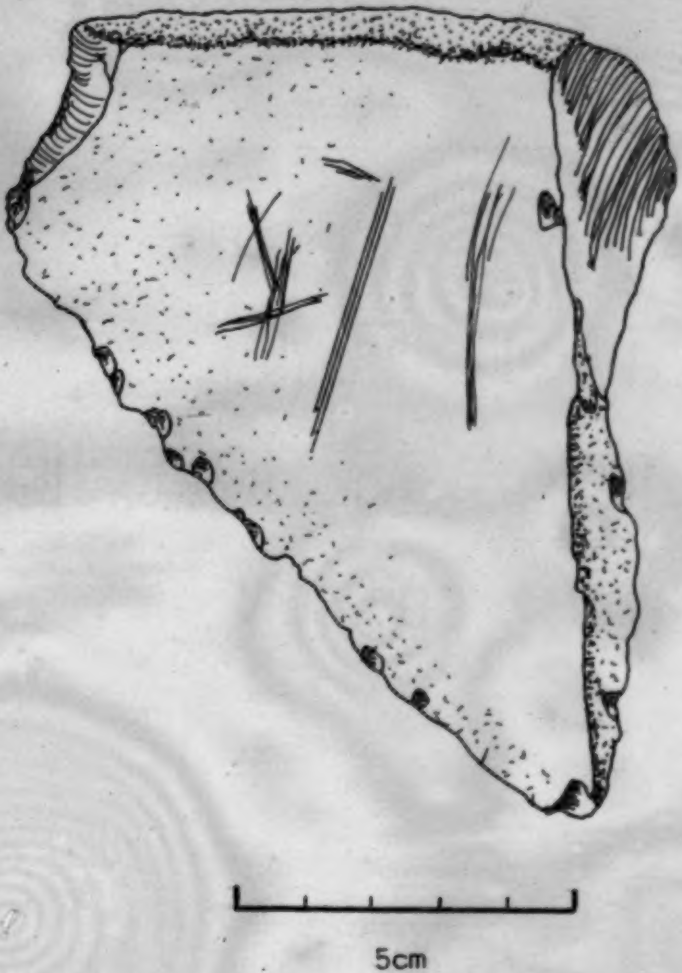


Figure 9. Large flake with striated dorsal surface.

dilemma of gloss applies to edge and ridge rounding because either solution and/or fluvial abrasion are capable of producing this phenomenon. Crushing, restricted to the ridges of flakes and present only on the edges of level bag clasts, is clearly related to glacial transport. The interpretation of microflaking of ridges and edges is more difficult. If the specimens are in fact man-made, then glacial abrasion could be ruled out. As will be shown later, fluvial action may be largely responsible for the majority of micro-flaking exhibited on flake edges. Ridge microflakes, are in all probability due to fluvial transport.

Characteristics of the Level Bag Specimens

Of the total collection of level bag specimens, 421 were examined from the standpoint of lithology, shape, metric characterization and weight. This number consists of approximately half of the available specimens. The selection of specimens for examination approximates a random sample as level bags were selected haphazardly from the box of bags, and the contents of each bag was examined completely.

From those level bags examined, 421 chert or siliceous siltstone clasts were recorded. To arrive at this figure, 70 level bags, representing all natural clasts of chert or siliceous siltstone recovered within a 1x2 m, 10cm level, were examined. Thus, a mean of approximately six natural clasts were recovered per 10cm level.

Chert was the dominant lithology present in the collection, accounting for 51% of the sample (Table 2). However, from the standpoint of the production of natural flakes, the high proportion of cherts is somewhat misleading in that the majority of these specimens are relatively small fragments, too small to serve as a source for the production of flakes in the Timlin collection. The size of these fragments is most certainly a property of the original size of the nodules in the Onondaga and Helderberg formations, as well as the presence of many internal flaws in these specimens leading to numerous structural weaknesses. This latter factor causes the chert nodules commonly to fracture along the internal flaws into angular fragments instead of fracturing conchoidally.

Table 3 provides comparative distributional data for weights of the two lithologies. The mean of the population of siliceous siltstone specimens is nearly twice that of the chert clasts. By way of comparison, the mean weight of flakes from the population of possible humanly-struck flakes is approximately 66 gms. As the average weight of flakes exceeds the average weight of the natural clasts, the majority of natural clasts are simply too small to have served as the cores from which the flakes were removed.

Level Bag Flake Scars

Several authors have published data comparing the flaking angle (Wilmsen's angle Beta) of naturally and humanly flaked stone clasts (e.g., Barnes 1939, Taylor and

Table 2

Raw Material Frequencies

Lithology	Absolute Freq	Relative Freq (Pct)	Adjusted Freq (Pct)	Cum Freq (Pct)
Indeterminate	1	0.2	0.2	0.2
Siltstone	79	18.8	18.8	19.0
Chert	341	81.0	81.0	100.0
Total	421	100.0	100.0	

Table 3

Weight Data for Level Bag Clasts

	Mean	Std. Error	Std. Dev.	Variance	Kurtosis	Skewness	Range	Minimum	Maximum	# of Specimens
All Clasts	55.27	4.25	87.10	7585.07	12.67	3.20	600.00	0.50	599.50	421
Siltstone	87.86	15.45	137.31	18854.19	5.17	2.33	600.00	0.80	600.00	79
Chert	47.89	3.73	68.80	4734.03	10.40	2.87	485.30	0.50	484.80	341

Payen 1979, Reeves 1980, Wilmsen 1970, Phagen 1976). For reasons discusssed previously, this concentration upon a single attribute is considered insufficient for the purposes of distinguishing human from natural flaking. Therefore, it was decided to observe values of the following additional attributes: 1) flake termination, 2) shape, 3) length and width parameters, and 4) place of origin of the proximal end of the flake scar (on an edge versus the surface of the clasts).

The following criteria were used to determine which flake scars were to be observed: 1) the entire negative flake scar must be present, from initiation to termination, and 2) flake scar length must exceed 1 cm in length. The cut-off point of 1 cm, while perhaps somewhat arbitrary, provides a degree of comparability in observations to other studies where a similar cutoff point was employed (Barnes 1939: Taylor and Payen 1979). In addition, the collection of flakes from the Timlin site does not include flakes in the less than 1 cm in length category.

For this analysis, the total collection of level bags was examined, yielding 66 clasts exhibiting one or more flake scars with the appropriate characteristics (Plate 4). From these clasts, a total of 99 flake scars were recorded, yielding an average of 1.5 flake scars per clast. Of these clasts, 39 were chert and 27 were siliceous siltstone. However, the siliceous siltstone specimens tended to possess more flake scars per clast than the chert specimens

Plate 4. Flaked level bag clasts.

(siliceous siltstone=1.8 scars/clast; chert=1.2 scars/clast).

The breakdown of observed flake scars by lithology is presented in Table 4. From these results it is apparent that while chert is the dominant lithology present in the deposits, flake scars of the appropriate dimension and morphology were produced with greater frequency on siliceous siltstone specimens. Again, this observation undoubtedly relates more to the inherent friability of chert clasts and their tendency to shatter along planes of weakness rather than producing conchoidal fractures, than to the greater "flakeability" of the siliceous siltstone clasts.

Descriptive statistics for length and width attributes of level bag flake scars are presented in Table 5. The means for these attributes are relatively small (1.696 and 2.221 for length and width respectively). However, the maximum values of over 6 cm in both dimensions are of comparable size to many of the flakes included in the Timlin collection. The length x width index present in Table 5, providing a gross estimate of flake surface area, will be valuable for comparison with a similar index calculated for the proposed population of humanly struck specimens. The length/width index, on the other hand, indicates proportions of linearity or squatness of the flake scars, with the value of 2 being traditionaly defined as the lower limit for the definition of a blade. From the descriptive statistics (Table 5) it is evident that the majority of flakes are

Table 4

Numbers of Flake Scars on Level Bag Lithologies

Category Label	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
Siltstone	51	51.5	51.5	51.5
Chert	48	48.5	48.5	100.0
Total	99	100.0	100.0	

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Table 5

Metric Attributes for Level Bag Flake Scars

	Mean	Std. Error	Std. Dev.	Variance	Kurtosis	Skewness	Range	Minimum	Maximum	# of Specimens
Length	1.70	0.09	0.91	0.83	10.41	2.90	5.70	0.80	6.50	99
Width	2.22	0.14	1.14	1.29	2.16	1.37	5.60	0.60	6.20	99
Length x Width	4.51	0.56	5.58	31.13	12.66	3.34	33.40	0.70	34.10	99
Length/Width	0.86	0.04	0.43	0.18	4.46	2.10	2.14	0.36	2.50	99

somewhat wider than long, with very few specimens being "blade-like" in proportions. The descriptive statistics can be summarized more visually by an examination of the flake scar shape categories in Table 6. In this table it is shown that approximately 9% of the flakes are parallel-sided, with the majority falling into the category of flake scars with the maximum width occurring at the extreme distal end. The low frequency of parallel-sided flake scars is most readily explained by the lack of previous flake scar ridges to guide the path of subsequent flakes.

The frequency of observed flake termination types is presented in Table 7. The distribution illustrated in this table provides a rather striking pattern of slightly over 70% of the flake scars possessing either hinged or step terminations. In controlled human flaking one generally expects the craftsmen to produce a higher percentage of feather terminated flakes. The presence of a high proportion of hinge and step terminations can be used to infer inadequate force amounts, an improper direction of force application (Phagen 1976: Crabtree 1972), or, in the case of step fractures, impurities or lines of weakness in the clasts.

Descriptive statistics for interval level measurements and the frequencies of the variable angle in 10 degree increments are presented in Table 8. The mean value for the attribute of flaking angle compares very favorably with mean values presented by Taylor and Payen (1979) and Barnes

Table 6

Flake Scar Morphology for Level Bag Clasts

Category Label	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
Irregular	5	5.1	5.1	5.1
Distal End Widest	67	67.7	67.7	72.7
Rectangular	3	3.0	3.0	75.8
Spatulate	13	13.1	13.1	88.9
Parallel	9	9.1	9.1	98.0
Expanding	2	2.0	2.0	100.0
TOTAL	99	100.0	100.0	

Table 7

Flake Terminations for Level Bag Clasts

Category Label	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
Hinge	33	33.3	33.3	33.3
Step	37	37.4	37.4	70.7
Feather	22	22.2	22.2	92.9
Off Edge	7	7.1	7.1	100.0
Total	99	100.0	100.0	

Table 8

Platform Angle

Angle in Degrees	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
40° to 50°	2	2.0	2.0	2.0
50° to 60°	3	3.0	3.1	5.1
60° to 70°	4	4.0	4.1	9.2
70° to 80°	12	12.1	12.2	21.4
80° to 90°	19	19.2	19.4	40.8
90° to 100°	24	24.2	24.5	65.3
100° or greater	34	34.3	34.7	100.0
Indeterminate	1	1.0	Missing	100.0
TOTAL	99	100.0	100.0	

Mean (94.86 degrees) Minimum (43 degrees) Maximum (158 degrees) Std. Dev. (90.95)

(1939), and is even a bit higher. Further, the percentage of specimens exhibiting angles of 90 degrees or greater is quite comparable (34.7 degrees). Thus the empirical generalization devised by Barnes for this context is further strengthened by the Timlin site level bag analysis.

Differences in Flake Scars by Lithology

Because there might exist differences in the kinds of flakes produced due to structural and mineralogial differences, it was decided to compare the values of each of the recorded attributes for the two different lithologies(Tables 9-15). From the tables comparing the relative frequency percentage of specimens for the attributes analyzed, it appears that the kinds and dimensions of flakes produced are roughly similar for all attributes except flake terminations. For this attribute, chert flake scars possess a relatively higher percentage of step and feather terminations with a correspondingly lower percentage frequency of hinge fractures. The reasons behind this observed discrepancy are not immediately obvious, particulary in the case of the increased feather terminations. The explanation for the relatively higher occurrence of step terminations in the case of the chert clasts is probably related to internal flaws in the nodules.

Natural Flakes From the Timlin Site

Analysis of flake scars on the level bag clasts indicate that in many cases flakes were removed periodically during the transport of these chert and siliceous siltstone

Table 9

Flake Scar Angle for Siltstone Clasts

Category Label	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
40° to 50°	1	2.0	2.0	2.0
70° to 80°	5	9.8	10.0	12.0
80° to 90°	8	15.7	16.0	28.0
90° to 100°	14	27.5	28.0	56.0
100° or Greater	22	43.1	44.0	100.0
Indeterminate	1	2.0	Missing	100.0
Total	51	100.0	100.0	

Table 10

Flake Soar Morphology for Siltstone Clasts

Category Label	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
Irregular	4	7.8	7.8	7.8
Distal End Widest	36	70.6	70.6	78.4
Rectangular	2	3.9	3.9	82.4
Spatulate	2	3.9	3.9	86.3
Parallel	6	11.8	11.8	98.0
Expanding	1	2.0	2.0	100.0
Total	51	100.0	100.0	

Table 11

Flake Scar Terminations for Siltstone Clasts

Category Label	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
Hinge	23	45.1	45.1	45.1
Step	17	33.3	33.3	78.4
Feather	9	17.6	17.6	96.1
Off Edge	2	3.9	3.9	100.0
Total	51	100.0	100.0	

Table 12

Flake Scar Angle for Chert Clasts

Category Label	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
40° to 50°	1	2.1	2.1	2.1
50° to 60°	3	6.3	6.3	8.3
60° to 70°	4	8.3	8.3	16.7
70° to 80°	7	14.6	14.6	31.3
80° to 90°	11	22.9	22.9	54.2
90° to 100°	10	20.8	20.8	75.0
100° or Greater	12	25.0	25.0	100.0
Total	48	100.0	100.0	

Table 13

Flake Scar Morphology for Chert Clasts

Category Label	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
Irregular	1	2.1	2.1	2.1
Distal end widest	31	64.6	64.6	66.7
Rectangular	1	2.1	2.1	68.8
Spatulate	11	22.9	22.9	91.7
Parallel	3	6.3	6.3	97.9
Expanding	1	2.1	2.1	100.0
Total	48	100.0	100.0	

Table 14

Flake Terminations for Chert Clasts

Category Label	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
Hinge	10	20.8	20.8	20.8
Step	20	41.7	41.7	62.5
Feather	13	27.1	27.1	89.6
Off Edge	5	10.4	10.4	100.0
Total	48	100.0	100.0	

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Table 15

Metric Data for Siltstone and Chert Level Bag Clasts

	Mean	Std. Error	Std. Dev.	Variance	Kurtosis	Skewness	Range	Minimum	Maximum	# of Specimens
Chert										
Flaking Angle	87.44	2.67	18.55	344.29	-0.11	-0.14	84.00	43.00	127.00	48
Length	1.61	0.14	0.99	0.98	13.15	3.36	5.70	0.80	6.50	48
Width	2.01	0.13	0.91	0.82	1.61	1.21	4.10	0.60	4.70	48
Length x Width	3.87	0.74	5.15	26.57	16.69	3.88	29.85	0.70	30.55	48
Length/Width	0.87	0.06	0.44	0.19	5.16	2.22	2.14	0.36	2.5	48
Siltstone										
Flaking Angle	101.98	2.94	20.81	433.12	1.33	0.45	115.00	43.00	158.00	50
Length	1.77	0.12	0.83	0.69	7.70	2.42	4.50	1.00	5.50	51
Width	2.41	0.18	1.29	1.67	1.44	1.23	5.60	0.60	6.20	51
Length x Width	5.12	0.83	5.93	35.26	11.42	3.07	33.32	0.78	34.10	51
Length/Width	0.85	0.06	0.42	0.17	4.20	2.04	1.90	0.38	2.27	51

clasts from some unknown locality to their eventual deposition in tills near the Timlin site. From this observation it is logical to assume that some of these flakes will be present in the tills and redeposited till sediments. Given that flake removal was a random process (i.e., it did not occur with greater frequency in some environmental situations than in others) it is probable that natural flakes would show considerable variability in the degree of subsequent mechanical abrasion.

The recognition of those flakes definitely produced during glacial transport rests upon the presence of striations on the ventral surface of flakes. From the Timlin site collection sample a total of nine flakes of siliceous siltstone were discovered exhibiting striations on their ventral surface. Less certain identification of natural flakes was made on the basis of shape, termination, and dorsal surface attributes as suggested by the analysis of level bag flake scars. In this category, a total of seven flakes were identified, giving a total of 16 tentatively identified natural flakes. It should be emphasized at this point that while the definite naturally flaked specimens were not included in the following technological analysis, the tentative natural flakes were, as they could not be confidently separated from the remainder of the collection on the basis of independent attributes.

Characteristics of the Natural Flakes

By comparison to the proposed humanly struck flakes the dimensions (length, width, thickness) of the natural flakes are rather small (Table 16). Similarly, the means for the 3 flake indexes are consistently smaller. However, the values for these variables compare favorably with those obtained from the flake scar analysis of the level bag clasts.

Proximal End Attributes

Distributional data for attributes of platform surface and platform preparation scars are presented in Tables 17 and 18. Although the sample size is extremely small, it is apparent that the majority of the specimens exhibit cortical platform surfaces, or surfaces that have been crushed and hinged (in this case) by mechanical abrasion of the edge of the parental nodule. Perhaps not suprisingly, two specimens exhibit pseudo-platform preparation scars. The crushing and hinging is very characteristic of the crushed edges of many of the the level bag nodules and the pseudo-platform preparation simply reflects edge crushing on what was to become the proximal end of a flake. The small flake scars on the proximal dorsal surface may relate to post-detachment damage in fluvial transport or damage that occurred prior to the removal of the flake.

Flaking angle measurements on the natural flakes correlate nicely with the angles from the level bag

Table 16

Metric Data for Natural Flakes

	Mean	Std. Error	Std. Dev.	Variance	Kurtosis	Skewness	Range	Minimum	Maximum	# of Specimens
Weight	11.96	3.94	11.82	139.74	4.23	2.01	38.40	1.80	40.20	9
Length	2.86	0.26	0.75	0.56	2.09	1.24	2.40	2.00	4.40	8
Width	2.81	0.48	1.36	1.84	0.90	0.77	4.30	1.10	5.40	8
Thick	1.04	0.16	0.43	0.18	-2.12	0.21	1.00	0.60	1.60	7
Length x Width	7.61	2.26	6.68	45.86	4.62	1.88	23.76	0.00	23.76	9
Length/Width	1.10	0.26	0.78	0.61	1.88	1.21	2.73	0.00	2.73	9
Flake Index	6.19	1.72	5.17	26.72	0.38	0.78	15.84	0.0	15.84	9
Platform Width	1.46	0.18	0.48	0.23	0.25	-0.31	1.50	0.70	2.20	7
Platform Depth	0.76	0.12	0.32	0.10	2.92	1.52	1.00	0.40	1.40	7

Table 17

Platform Surface for Natural Flakes

Category Label	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
Indeterminate	2	22.2	22.2	22.2
Cortex	6	66.7	66.7	88.9
Crushed and Hinged	1	11.1	11.1	100.0
Total	9	100.0	100.0	

Table 18

Platform Preparation Scars for Natural Flakes

Category Label	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
Indeterminate	1	11.1	11.1	11.1
No Scars	6	66.7	66.7	66.7
1 to 3 Scars	1	11.1	11.1	88.9
Mass of Hinges	1	11.1	11.1	100.0
Total	9	100.0	100.0	

flake scars, as well as other published data referred to previously (Table 19). Although the sample size is too small to employ descriptive statistics usefully, it is obvious from a visual inspection of Table 19 that a large number of the specimens possess angles greater than 90 degrees, with a mean in the 89-90 degree interval.

Terminations

From the analysis of the level bag flake scars one would expect a high frequency of either step or hinge terminations. Unfortunately, terminations were indeterminate on the majority of specimens due to snapping of the lateral distal portions. However, this observation is significant in that it supports the hypothesis of mechanical attrition of the edges of flakes transported in glaciers. Nonetheless, three of nine specimens exhibit either hinged or stepped terminations (Table 20).

Dorsal Surface Morphology

An attribute measuring the occurrence of cortex on the dorsal surface of naturally-flaked specimens is somewhat redundant because, by definition, cortex refers to cortical surface material that was not exposed through human activity. Therefore, by definition all specimens exhibit 100% cortex on their dorsal surface. The same reasoning holds true for the flake scars present on the dorsal surface of several specimens,

Table 19

Flaking Angle Values for Natural Flakes

	Absolute Freq	Relative Freq (Pct)	Cum Freq (Pct)
70° to 80°	1	12.5%	12.5%
80° to 90°	4	50.0%	62.5%
90° to 100°	3	37.5%	100.0%
Total	8	100.0%	

Table 20

Flake Terminations for Natural Flakes

Category Label	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
Indeterminate	5	55.6	55.6	55.6
Feather	1	11.1	11.1	66.7
Stepped	1	11.1	11.1	77.8
Hinged	2	22.2	22.2	100.0
Total	9	100.0	100.0	

Table 21

Dorsal Surface Scars on Natural Flakes

Category label	Absolute Freq	Relative Freq (pct)	Adjusted Freq (pct)	Cum Freq (pct)
None	4	44.4	44.4	44.4
One Scar	4	44.4	44.4	88.9
Three Scars	1	11.1	11.1	100.0
Total	9	100.0	100.0	

though in this case recording of this attribute is significant in terms of a comparison with the proposed humanly struck flakes in the Timlin collection. From Table 21, it is clear that the presence of dorsal surface flake scars is not unexpected on naturally produced flakes.

F. Discussion

The preceding analysis of natural flakes and flake scars on level bag clasts indicates several important trends in particular attributes that are significnt in terms of distinguishing glacially produced flakes from those produced by humans. However, it must be borne in mind that none of these attributes or attribute states are mutually exclusive to either human or glacial flaking.

Firstly, this analysis adds further empirical support to Barnes's generalization regarding distributions of values for angles-platform scar measurements. As suggested earlier, a high percentage of obtuse measurements is expected in a very high energy, low velocity sub-glacial environment.

In addition, where a large number of whole flakes are present, flake terminations would appear to be a powerful attribute in distinguishing glacial flakes from human flakes. However, it is possible that high percentages of right angle terminations (hinge and step) may be due to other causes when dealing with different lithologies or very specialized human technologies.

Platform attributes confirm the expected pattern for natural flaking with the low occurrence of platform faceting or psuedo-platform preparation scars. However, it was shown that even in as small a sample as the nine natural flakes in the Timlin collection, a certain amount of platform alteration is to be expected.

Dorsal surface characteristics (number of flake scars and percent cortex) proved less valuable. If glacial striations overrunning flake scars or cortical surfaces were absent it would be difficult to assess the origin of these scars.

G. Flake Analysis

The Timlin site collection consists of 128 identifiable flakes and flake fragments (Table 22). Of these flakes, 108 are complete; and 19 are either proximal, distal, or lateral fragments.

Raw Materials

The lithological breakdown of flakes by raw material type is given in Table 23, showing that the dominant lithology (86%) of the flakes is brown silicified siltstone. Ten percent were detached from brown chert nodules, with the remaining specimens consisting of black silicified limestone and a blue chert. The source of the black silicified limestone is unknown at present; but it is assumed that this material, as well as all other lithologies in the collection can be found locally in fluvial or glacial deposts.

Table 22

Categories of Possiblefacts

Category Label	Absolute Freq	Relative Freq (Pct)	Adjusted Freq (Pct)	Cum Freq (Pct)
Indeterminate	6	4.3	4.3	4.3
Complete Flake	108	77.7	77.7	82.0
Proximal Fragment	6	4.3	4.3	86.3
Distal Fragment	10	7.2	7.2	93.5
Lateral Fragment	3	2.2	2.2	95.7
Core Fragment	1	0.7	0.7	96.4
Shatter	4	2.9	2.9	100.0
Total	139	100.0	100.0	

Table 23

Raw Material Types for Possiblefacts

Category Label	Absolute Freq	Relative Freq (Pct)	Adjusted Freq (Pct)	Cum Freq (Pct)
Siltstone	86	86.0	86.0	86.0
Chert	10	10.0	10.0	96.0
Black Siltstone	2	2.0	2.0	98.0
Blue Chert	2	2.0	2.0	100.0
Total	100	100.0	100.0	

The greater percentage of flakes of silicified siltstone compared to their rate of occurrence in the level bag specimens (18.8% siltstone, 81% chert) does not support a random fracture model of natural flaking. These data suggest some form of selection, either by humans or some natural process. Of course, these data must be balanced with the rate of flaking of natural nodules where chert and siliceous siltstone are approximately equal in representation.

Metric Description

Descriptive statistics for weight, length, width, thickness, and the three flake indexes are presented in Table 24. These data provide a gross statement of the size distributions for these variables, and are valuable in comparision to the size and dimension of level bag flakes and flake scars.

Descriptive statistics for the weight variable indicate a mean of approximately 65 gm, a medium sized flake, with a range of 476 gm (from 2.2 gm to 478.2 gm). This measurement indicates that from small to extremely large flakes (e.g., Figure 10) are included in the sample. The skewness value indicates a clustering of cases to the right of the mean.

Length and width distributions indicate near normal distributions around a mean of approximately 5 cm. Means for these variables contrast sharply with those from the level bag flake scars (L=1.696; W=2.221). In addition, the maximum values for these variables (L=13.1); W=11.7) fall well

Table 24

Metric Data for Timlin Flakes

	Mean	Std. Error	Std. Dev.	Variance	Kurtosis	Skewness	Range	Minimum	Maximum	# of Specimens
Weight	65.92	8.42	87.51	7657.97	7.06	2.56	476.00	2.20	478.20	108
Length	5.87	0.22	2.31	5.37	0.11	0.58	11.30	1.80	13.10	107
Width	5.09	0.21	2.12	4.51	-0.10	0.39	10.70	1.00	11.70	106
Thickness	1.71	0.21	2.19	4.83	78.41	8.270	22.30	0.30	22.60	107
Flaking Angle	68.09	1.30	13.25	175.69	2.85	0.48	95.00	30.00	125.00	104
Length x Width	1.28	0.08	0.87	0.75	42.34	5.46	8.40	0.00	8.40	108
Length/Width	32.28	2.35	24.48	599.18	2.17	1.40	120.90	0.00	120.91	108
Flake Index	20.46	0.93	9.63	92.82	0.35	0.55	49.64	0.00	49.64	108

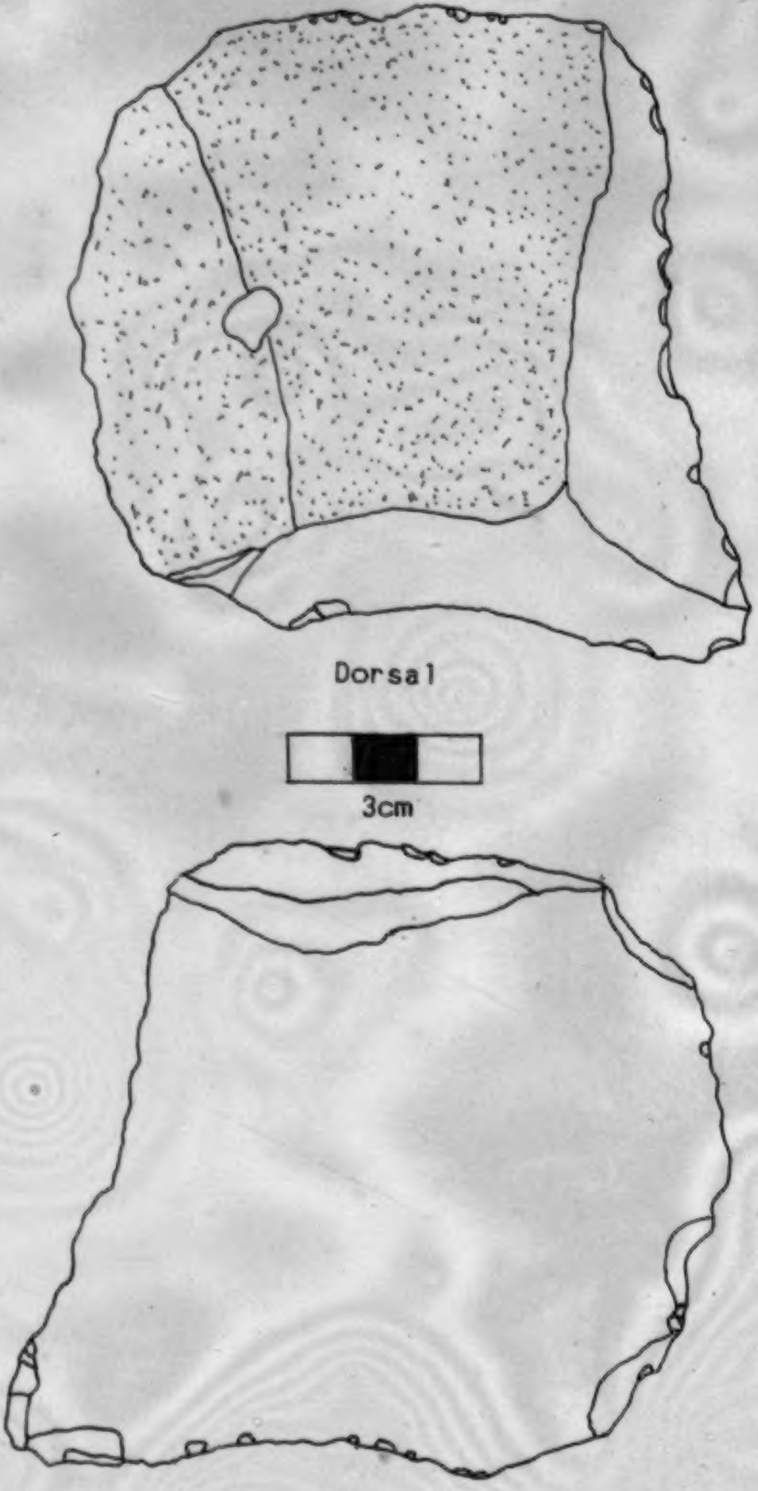

Dorsal
3cm
Ventral

Figure 10. Large flake in the Timlin collection.

outside the range for these variables on level bag specimens.

Descriptive statistics for flaking angle are presented in Table 25. Flaking angles for Timlin site flakes compare very favorably with published statistics for flaking angles in other controlled fracture situations (Taylor and Payen, 1979; p. 266).

Approximately 2.6% of the flaking angles exceed 90 degrees, a sufficiently low value to satisfy the Barnes criterion for human workmanship. Further, the level bag mean of approximately 94.8 degrees contrasts sharply with the 64 degree mean of the Timlin site flakes, but agrees very nicely with published distributions for flaking angles in natural situations (Taylor and Payen 1978: p. 268-269).

Useful information can be derived from three other statistics describing flake proportions. Table 24 presents descriptive statistics for the L x W index, L/W index and the flake index. The length x width index provides a rough approximation of fracture surface area and is, therefore, roughly proportional to the force of detachment (Phagen, 1976; p 77). By itself, this index is not particularly meaningful, though its significance can be estimated when compared with L x W values from other published sites. The range of 0.0 to 121 approximates a normal distribution as indicated by skewness and kurtosis values. This distribution of values indicates that the majority of flakes are fairly large, but ranging between small and very large flakes. By

Table 25

Flaking Angle Values for Timlin Flakes

Category Label	Absolute Freq	Relative Freq (Pct)	Adjusted Freq (Pct)	Cum Freq (Pct)
20° to 30°	1	0.9	1.0	1.
30° to 40°	1	0.9	1.0	1.9
40° to 50°	6	5.6	5.6	7.7
50° to 60°	18	16.7	17.3	25.0
60° to 70°	36	33.3	34.6	59.6
70° to 80°	29	26.9	27.9	87.5
80° to 90°	10	9.3	9.6	97.1
90° to 100°	2	1.9	1.0	99.0
100° and greater	1	0.9	1.0	100.0
Indeterminate	4	3.7	Missing	
Total	108	100.0	100.0	

comparison to length x width values for level bag flake scars, the mean for the Timlin proposed human collection is very near the maximum value for natural flake scars presented earlier.

Similarly, the L x W index illustrates that Timlin flakes are consistently longer relative to width, while level bag flake scars, in the majority of cases, are nearly rounded or squared.

Flake Index

According to Phagen (1976) the flake index should give a rough estimate of the degree of control exerted over fracture variables. However, this index only makes sense when compared with published values from other sites. The flake index values for the Timlin site compared with sites analyzed by Phagen indicate that little control was exerted over fracture variables so that flake thickness is relatively high in comparison to length and width parameters.

The remaining groups of attributes measure or describe characteristics of the proximal end, distal end, the dorsal surface, and ventral surface. Proximal end attributes provide information regarding the amount of surface preparation prior to flake removal (platform scars, platform surface), the position of the PFA from the core edge (platform remnant depth), and the degree of isolation of the platform (platform remnant width). The distal end attribute of termination used in this study is significant for several reasons. Flake terminations are, to a certain degree, indicative of the proper control of force direction, amount, and placement. Together these properties consist of what Warren (1914) referred to as controlled flaking. Given that the knapper does not intend to produce hinged or step terminations, then the frequency of feathered terminations is proportional to the degree of control exerted over the flaking process. Stepped terminations "may indicate inadequate force amounts delivered with an outward component" (Phagen 1976: 51), while hinge terminations indicate an inadequate force amount to achieve a feathered termination.

Dorsal surface characteristics (percent of remaining cortex; scar number, size and arrangement), similar to the proximal end attributes, provide an index of the amount of previous flake removals, either cultural or natural. Patterning in size and arrangement may point more strongly to a cultural origin although the reverse is not necessarily true.

Proximal End Attributes

Descriptive statistics for continuous variables of platform dimensions are given in Table 26. These statistics describe a population of platforms which are on the average rather deep (mean=.922) and wide (mean=2.207) with a higher percentage of the specimens occurring to the right of the mean. The means for the Timlin site flakes compare well with similar measurements from other assemblages and bear out

Table 26

Metric Data for Platform Attributes (mm)

	Mean	Std. Error	Std. Dev.	Variance	Kurtosis	Skewness	Range	Minimum	Maximum	# of Specimens
Platform Depth	1.11	0.19	1.92	3.68	75.39	9.16	18.90	0.10	19.00	103
Platform Width	2.48	0.29	2.99	8.99	60.71	7.00	28.70	0.30	29.00	103

this observation (avg. 4.1 mm from Phagen, 4mm from Wilmsen; width under 9mm from Wilmsen, and 4mm from Phagen). Little can be said about comparing these values to those observed on the natural flakes due to the small number of definite natural flakes. It can only be noted that the mean values for the proposed human assemblage are considerably greater for both of these measurements.

Platform preparation scars

The distribution of values for this variable given in Table 27 indicates a low frequency of fracturing around the platform area that appears to result from preparation of the flake prior to flake removal. Plate 5 illustrates several flakes exhibiting platform preparation scars. Less than 30 percent of the assemblage exhibits one or more proximal flake scars. In addition, observations regarding the incidence of pseudo-platform preparation on natural specimens (flake scars originating from the proximal end not caused by human action) indicates that this variable is not completely reliable in discriminating between populations of natural and humanly-produced specimens.

Platform Surface

The high incidence of indeterminate observations (Table 28) for this variable reflects the degree of chemical weathering these specimens have undergone, and consequently the difficulty in determining whether or not a platform surface consists of a single facet or a cortical surface. However, approximately 51% of the flakes exhibit from one to

Table 27

Platform Preparation Scars on Timlin Flakes

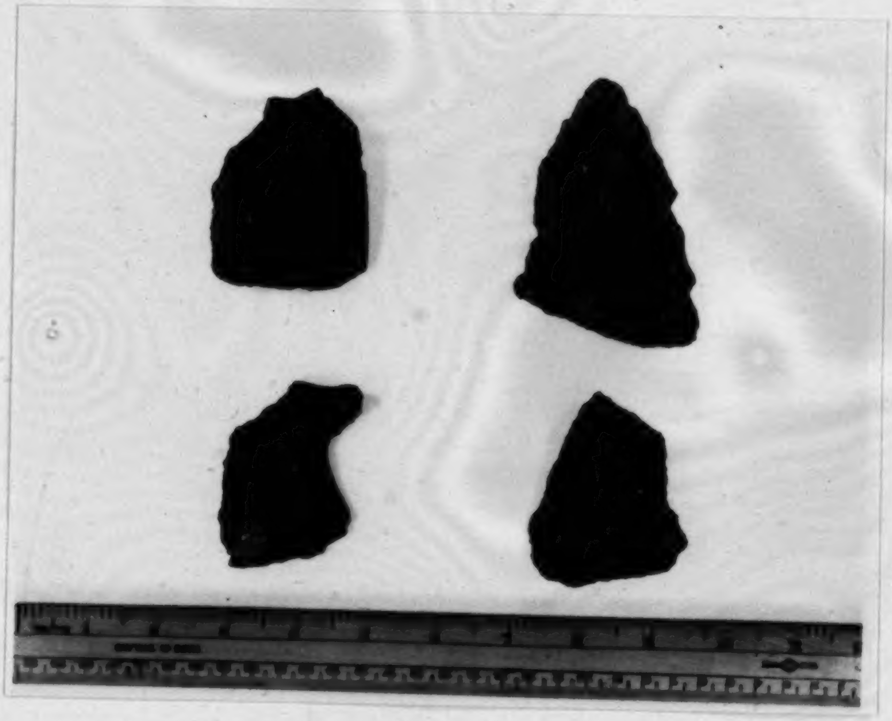
Category Label	Absolute Freq	Relative Freq (Pct)	Adjusted Freq (Pct)	Cum Freq (Pct)
Indeterminate	9	~~9.0~~	9.0	9.0
No Scars	61	~~61.0~~	61.0	70.0
1 to 3 Scars	19	~~19.0~~	19.0	89.0
4 to 6 Scars	3	3.0	3.0	92.0
Mass of Hinges	8	8.0	8.0	100.0
Total	100	100.0	100.0	

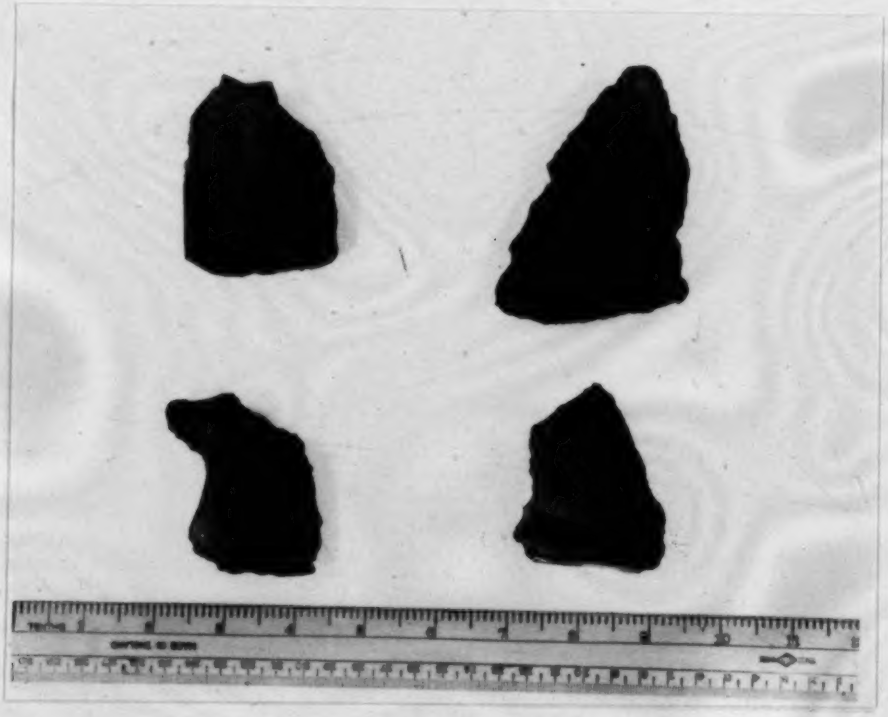
Table 28

Platform Surface Morphology on Timlin Flakes

Category Label	Absolute Freq	Relative Freq (Pct)	Cum Freq (Pct)
Indeterminate	16	16.0	16.0
Cortex	26	26.0	42.0
Single Flake Scar	40	40.0	82.0
2 to 3 Scars	14	14.0	96.0
Series of Small Scars	2	2.0	98.0
Crushed and hinged	1	1.0	99.0
Ground	1	1.0	100.0
Total	100	100.0	

Plate 5. Timlin flakes exhibiting platform preparation.





three flake removals on their platform, the majority consisting of only a single facet.

Distal End Attributes

Flake terminations for Timlin flakes are presented in Table 29. As mentioned previously, flake terminations reflect the degree of control over flake production, from the standpoint of proper force amounts and direction of force application. Table 29 illustrates that for whole flakes, nearly 80% of the specimens possess feather terminations. The percent occurrence of hinge fractures, however, is rather high (14.8%) when compared with published data. Comparison of termination attributes on level bag flake scars is particulary instructive. For these specimens, hinge and step terminations account for approximately 70% of the observed flake occurrences.

Dorsal Surface Characteristics

In most humanly flaked stone industries, a great percentage of flakes exhibit evidence of prior flake removals in the form of dorsal surface ridges. As such, each individual flake scar represents a distinct event prior to the removal of the flake under consideration. That this reasoning is not always necessarily the case has been illustrated by Bradley, et al. (1972) who demonstrated that, in some instances, a single blow can detach two flakes, one superimposed on the other. However, if this were the case, the direction of propagation of the secondary and primary flake should be exactly the same. In addition, the proximal

Table 29

Flake Terminations for Timlin Flakes

Category Label	Absolute Freq	Relative Freq (Pct)	Adjusted Freq (Pct)	Cum Freq (Pct)
Indeterminate	4	4.0	4.0	4.0
Feather	81	81.0	81.0	85.0
Stepped	1	1.0	1.0	86.0
Hinged	14	14.0	14.0	100.0
Total	100	100.0	100.0	

Table 30

Dorsal Surface Scars

Category Label	Absolute Freq	Relative Freq (Pct)	Adjusted Freq (Pct)	Cum Freq (Pct)
None	16	16.0	16.0	16.0
One Scar	16	16.0	16.0	32.0
Two Scars	20	20.0	20.0	52.0
Three Scars	10	10.0	10.0	62.0
Four Scars	17	17.0	17.0	79.
Five Scars	10	10.0	10.0	89.0
Six Scars	6	6.0	6.0	95.0
Seven Scars	1	1.0	1.0	96.0
Eight Scars	3	3.0	3.0	99.0
Nine or More Scars	1	1.0	1.0	100.0
Total	100	100.0	100.0	

Table 31

Percent Cortex on Dorsal Surface

Category Label	Absolute Freq	Relative Freq (Pct)	Cum Freq (Pct)
Indeterminate	3	3.0	3.0
No Cortex	24	24.0	27.0
Less Than One Quarter	18	18.0	45.0
One Quarter to One Half	24	24.0	69.0
One Half to Three Quarters	11	11.0	80.0
More Than Three Quarters	7	7.0	87.0
All Cortex	13	13.0	100.0
Total	100	100.0	

initiation morphology should be present as well.

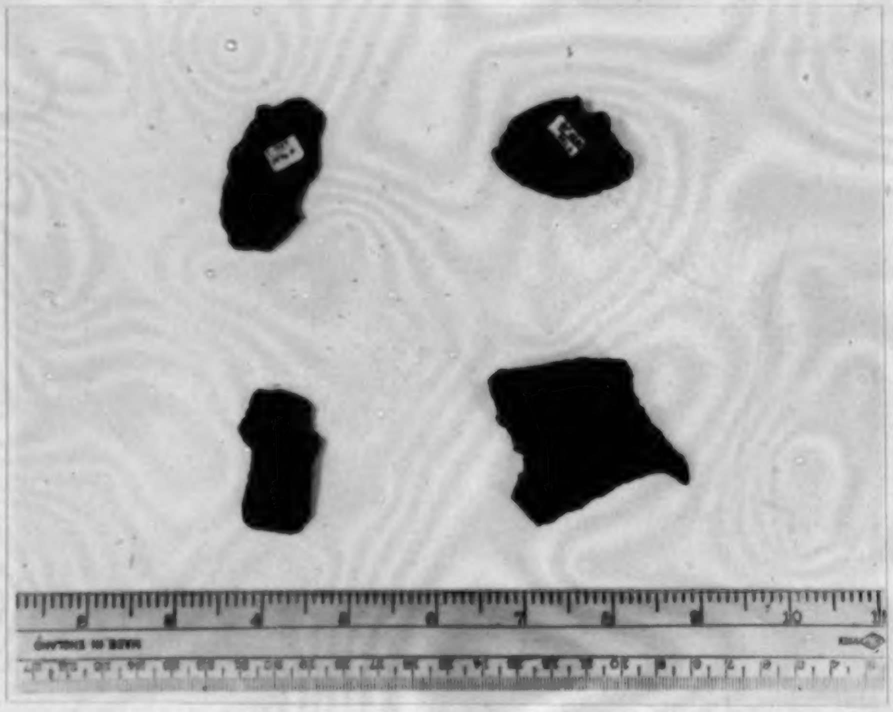
Thus, the number of flake scars on specimens and the amount of cortex remaining on the dorsal surface are useful interpretive attributes in distinguishing natural from human flaking. In the Timlin collection, approximately 18% (Table 30) of the flakes lack flake scars and, therefore, exhibit cortex over the entire dorsal surface. Plate 6 and Figures 11-13 illustrate specimens exhibiting one or more dorsal surface scars. The lower specimen on Figure 13 has been extensively retouched on the dorsal surface with more minimal alteration of the ventral surface.

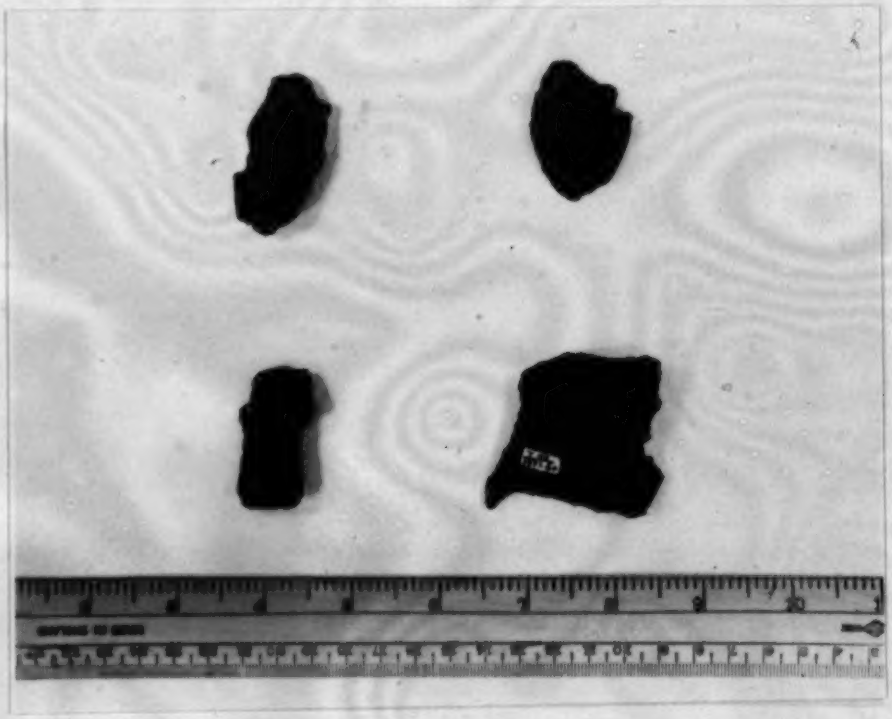
The percent of the dorsal surface covered by cortex is presented in Table 31. These data indicate that well over 50% of the specimens exhibit from 1/2 to all of the dorsal surface free of cortex. When combined with the data supplied in Table 30 it is apparent that while the majority of the specimens have had at least half of their cortical surface removed, the removal was accomplished with only a few, relatively large flakes. Figure 14 illustrates two flakes lacking any cortex on the dorsal surface. Figure 15 illustrates specimens exhibiting cortex over the entire dorsal surface.

H. Summary and Discussion

In the preceding section, a number of attributes of flake form and production were reviewed from a technological standpoint. It was stressed earlier that none of these

Plate 6. Small flakes exhibiting complete removal of dorsal surface cortex.





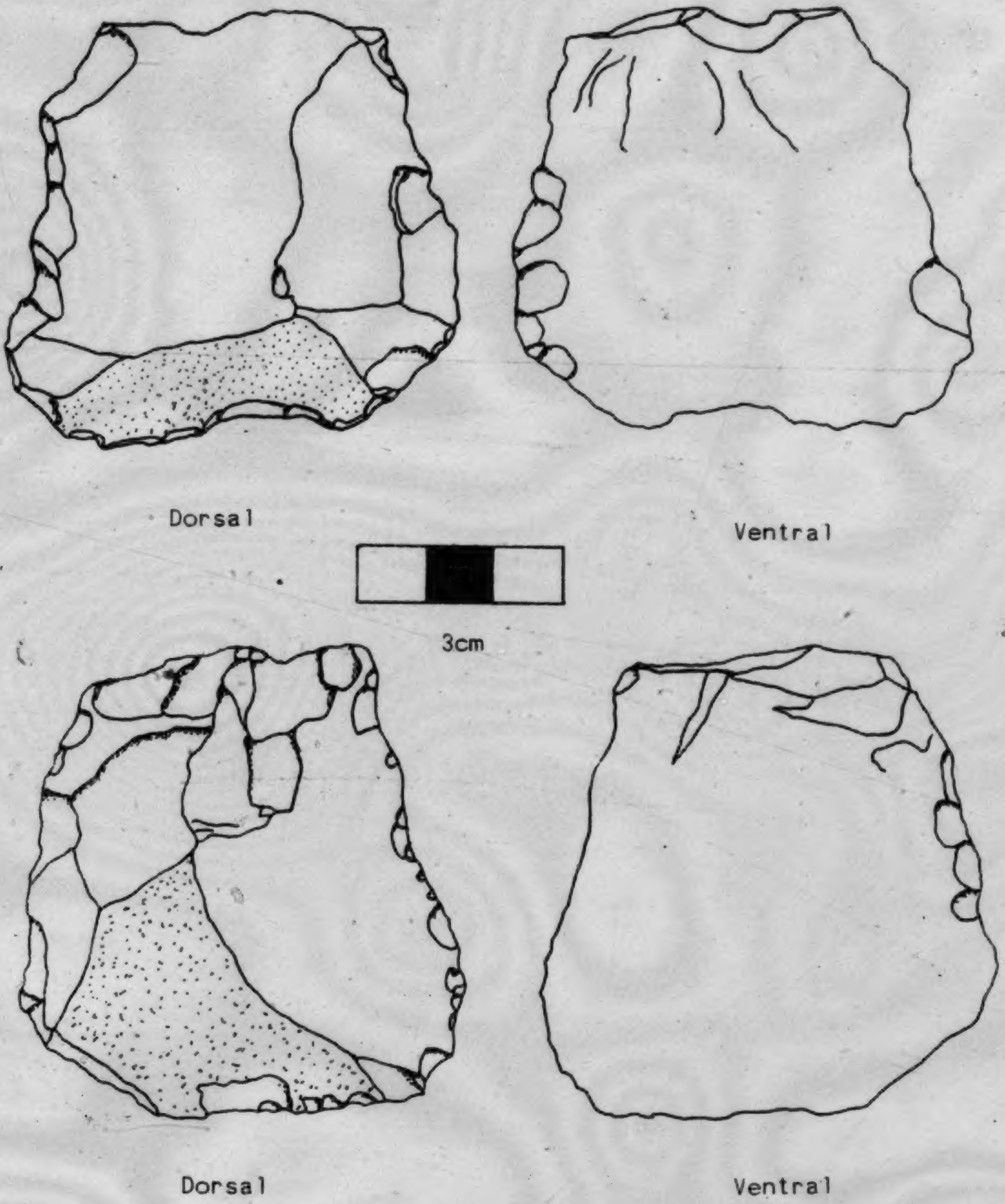

Dorsal
Ventral
3cm
Dorsal
Ventral

Figure 11. Flakes with dorsal surface flake scars.

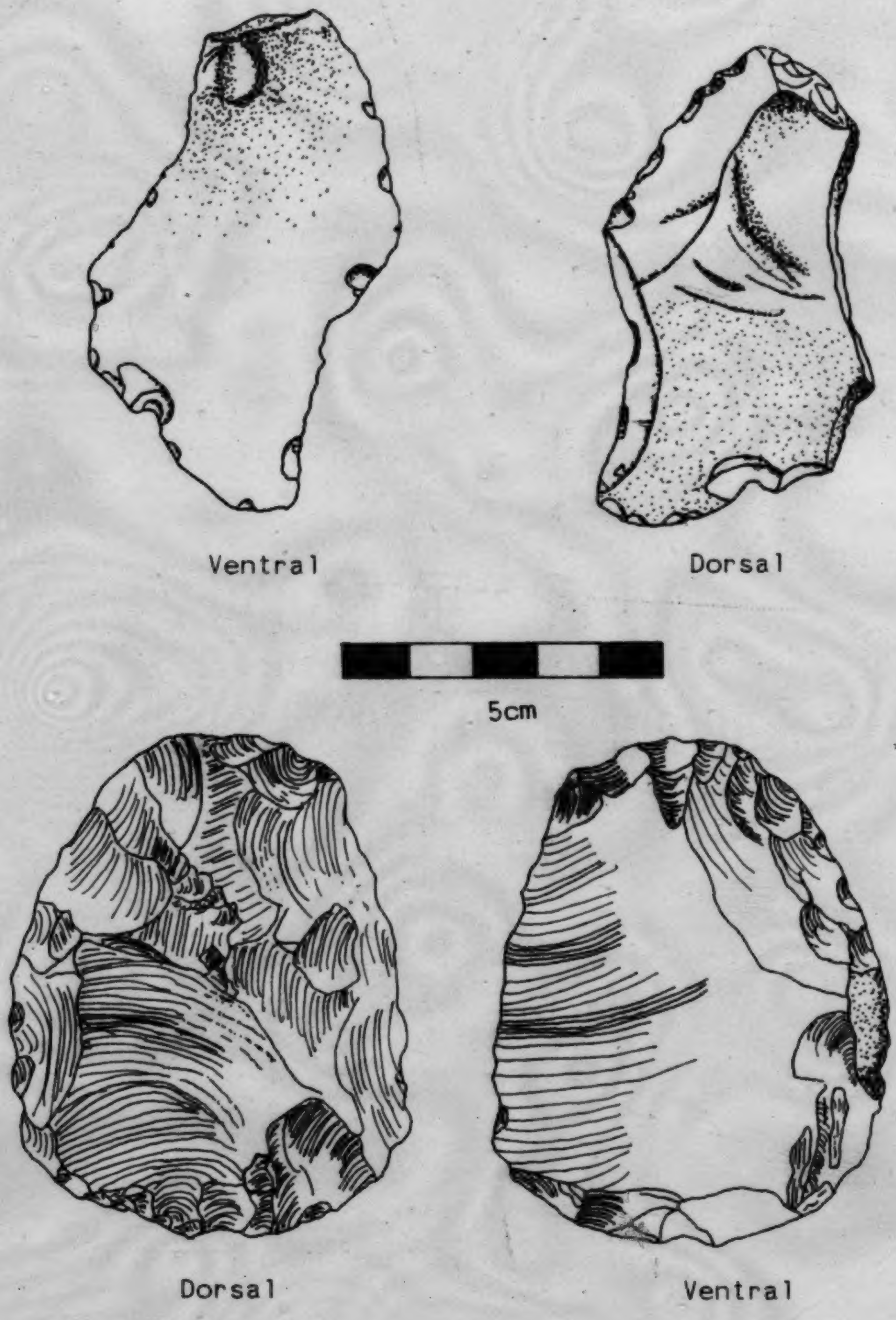

Ventral
Dorsal
5cm
Dorsal
Ventral

Figure 12. Flakes with dorsal surface flake scars.

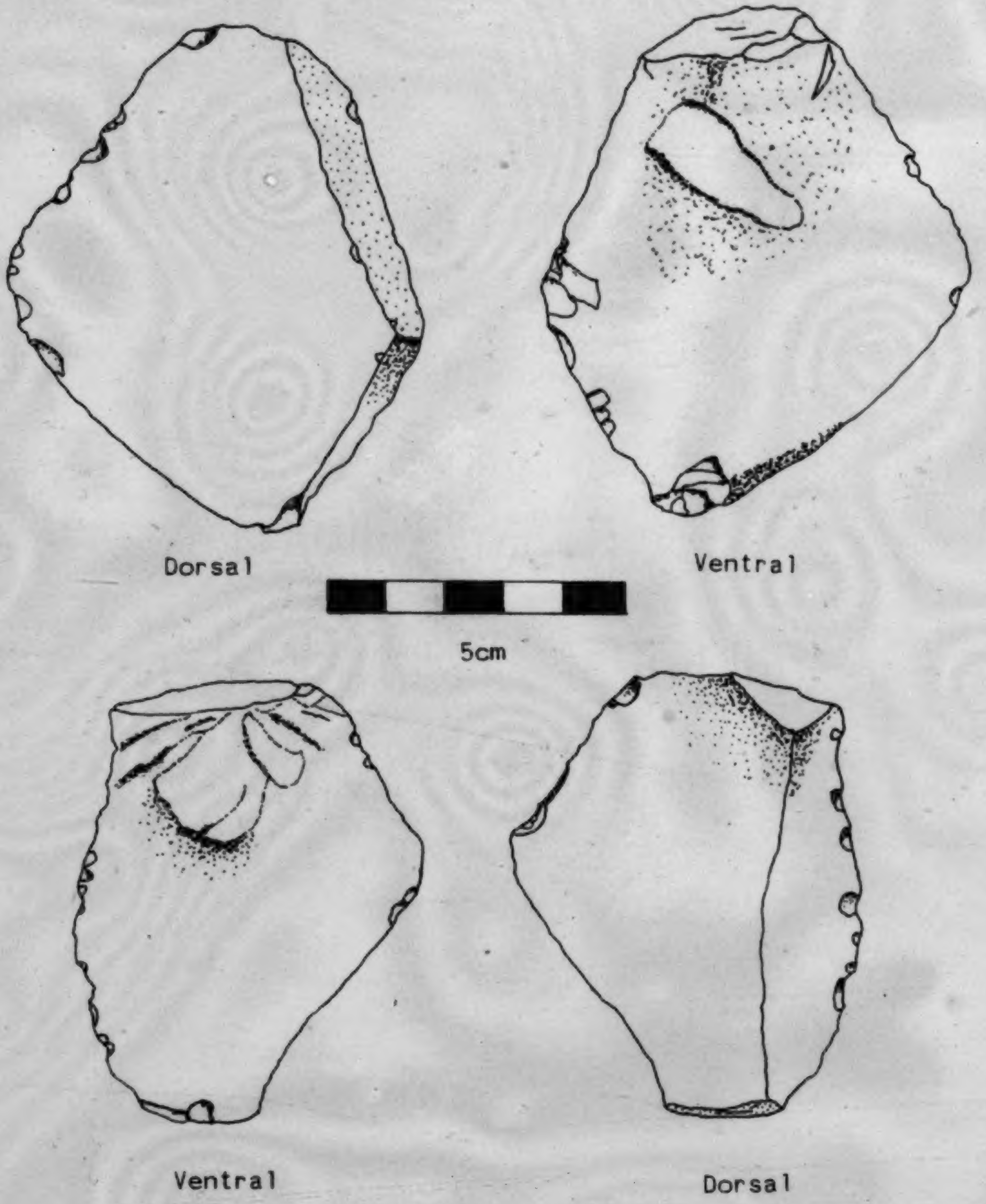

Dorsal
Ventral
5cm
Ventral
Dorsal

Figure 13. Flakes with dorsal surface flake scars.

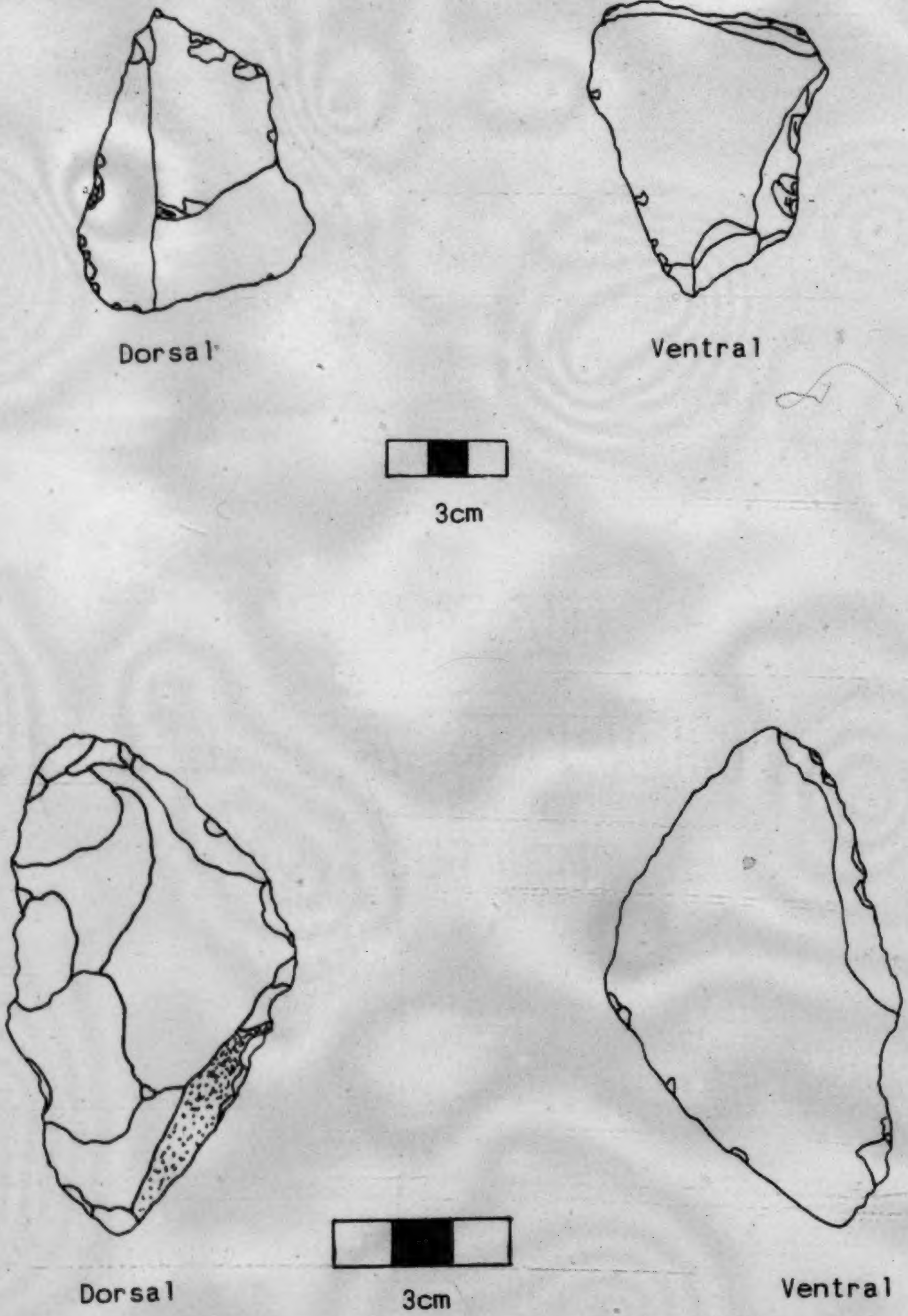

Dorsal
Ventral
3cm
Dorsal
3cm
Ventral

Figure 14. Flakes lacking cortex on dorsal surface.

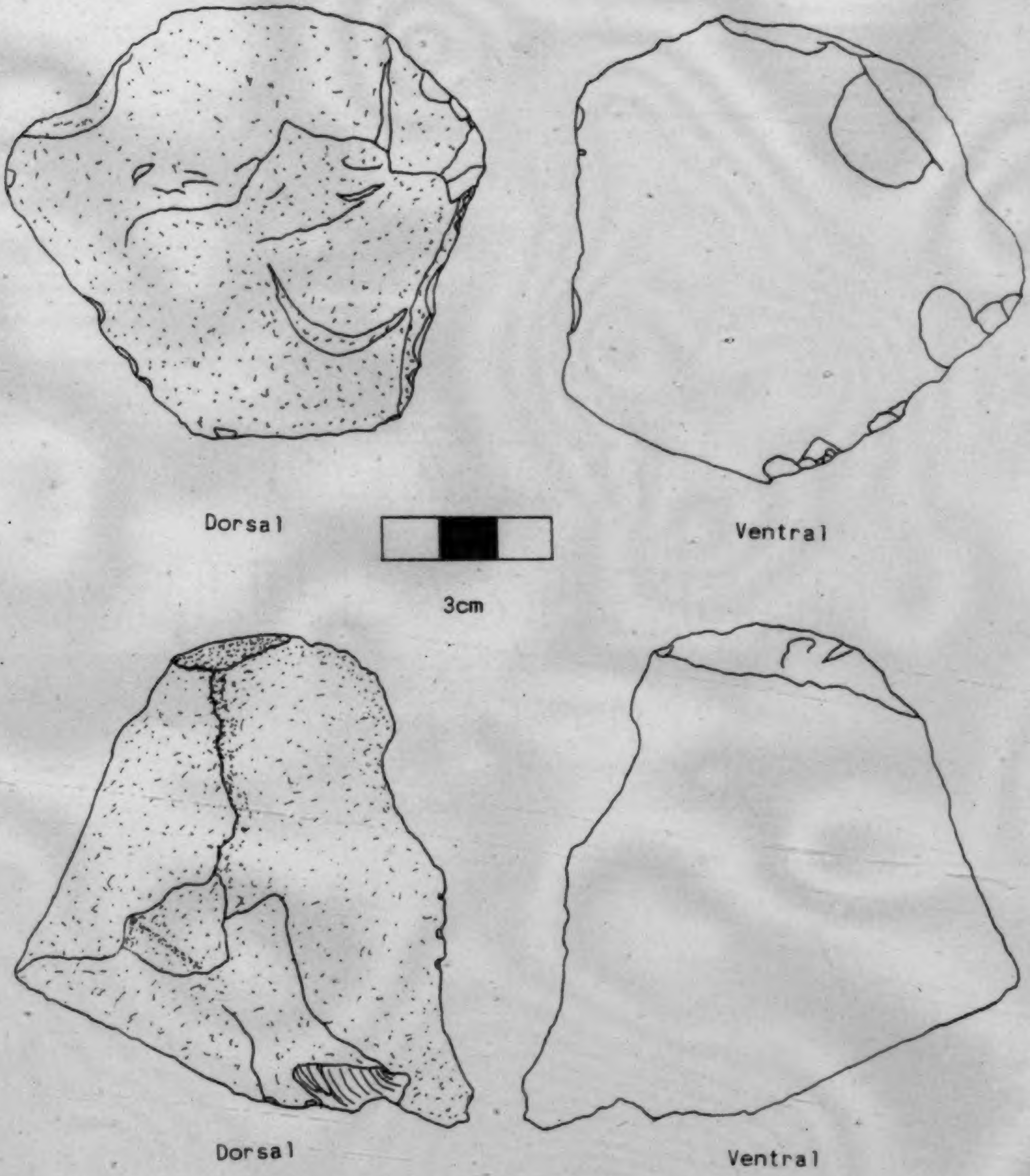

Dorsal
Ventral
3cm
Dorsal
Ventral

Figure 15. Flakes with cortex covering dorsal surface.

attributes are in any sense exclusively characteristic of humanly produced flakes. This point was brought home by the observation of these same attributes on the small sample of naturally produced flakes. However, in many cases, examination of the distribution of values for these variables has shown them to be distinctly different from their distribution in naturally flaked specimens.

I. Cores and Core Fragments

Five possible cores and core fragments were recovered from Locus 1-C. The lithology of these specimens is in each case the same patinated brown siliceous siltstone as the majority of flakes. Although the degree of patination is variable between specimens, flake scar surfaces on individual specimens are patinated to roughly the same degree.

Recognition of these specimens as possible human products relates to their general morphology and lack of features indicative of glacial transport. Specifically, striations and heavily crushed edges and ridges are located only on unflaked, cortical surfaces. Further, each specimen exhibits numerous flake removals so that the original shape of the nodule has been significantly altered, or shaped.

For each core, flakes were detached at flaking angles less than 90 degrees. The vast majority of terminations of larger flakes (greater than 3cm) are feathered. Smaller flakes exhibit considerable variation in terminations, most of which are feathered with a fair number of hinged terminations.

In all but one case, cortical surface area of these specimens consists of less than 1/4 of the total surface area. The former specimen, with flakes detached from only two faces, retains nearly 50% of the cortical surface.

J. Discussion

Possible cores and core fragments differ systematically from the level bag clasts exhibiting one or more flake removals. Significant differences exist in the degree of alteration and shaping, the angles at which flakes were removed, and their distal morphology. In addition, in no instance do striations overrun flaked surfaces.

K. Micromorphological Alterations

As described previously, the majority of flakes and flaked nodules (core and/or core fragments) exhibit microflaked edges of variable intensity and distribution. With the aid of a binocular microscope, rounded edges are visible on all edges even where no microflaking is present. The identification of the mechanism responsible for the edge damage present on these specimens (cultural or natural) is crucial for a proper cultural interpretation of the collection. In many respects the problem presented by the edge damage on the Locus 1-C speciemens resembles the Clactonian problem discussed in Chapter II (Ohel 1978). If these specimens in fact represent a distinctive archaeological industry, qualitatively different from known Holocene industires from eastern North America (Bryan et al., 1980), then the edge damage on Timlin specimens would have to be identified as primarily cultural in origin. If, on the other hand, the observed damage can be demonstrated to be the result of natural processes, the case for a distinctive industry of stone tools would be greatly weakened. In this latter case, a quarry/workshop hypothesis would seem to be a more reasonable interpretation.

Rounded edges and dorsal ridges must be considered as natural in origin, caused by the abrasive wear of sand and silt-sized particles in the stream environment. Although edges and ridges may have been rounded and polished thru cultural activities prior to fluvial transport, subsequent wear in the stream has effectively removed any possible traces. As demonstrated by specimens in the Savage River Experiment, this kind of abrasive wear takes place quite rapidly, and necessitates little or no movement of specimens (Appendix I). The rapidity with which these alterations occur makes it impossible to detect use-wear in the form of edge-polishing, or of striations located on and near the edge.

The origin of microflakes on flake perimeters is less easily assessed. On nearly all specimens this edge damage consists of isolated, randomly distributed flake scars of varying intensity. Many of the tabular chert specimens from the level bags also exhibit this form of edge damage on acute angled edges. It was demonstrated in the Savage River experiment that this kind of alteration can take place relatively quickly in fluvial environments. This experiment indicated that edge microflaking is accompanied by less intensive removal of microflakes on flake scar ridges. Similar damage has been noted on the Timlin flake scar ridges.

In all probability the edge damage noted on the Timlin specimens is natural in origin, resulting from vibration in place in a stream characterized locally by high turbulent velocities. This damage could have occurred quite quickly and necessitated very little net horizontal movement. The edge damage exists on all size classes, with more intensive larger flake removals on large flakes and smaller flake removals on very small flakes (e.g., Figure 16).

Three specimens exhibit edge damage that is, in all probability the result of human edge retouch. These specimens include the extensively modified flake illustrated at the bottom of Figure 13 and two others exhibiting closely-spaced, parallel retouch of a single flake edge perimeter.

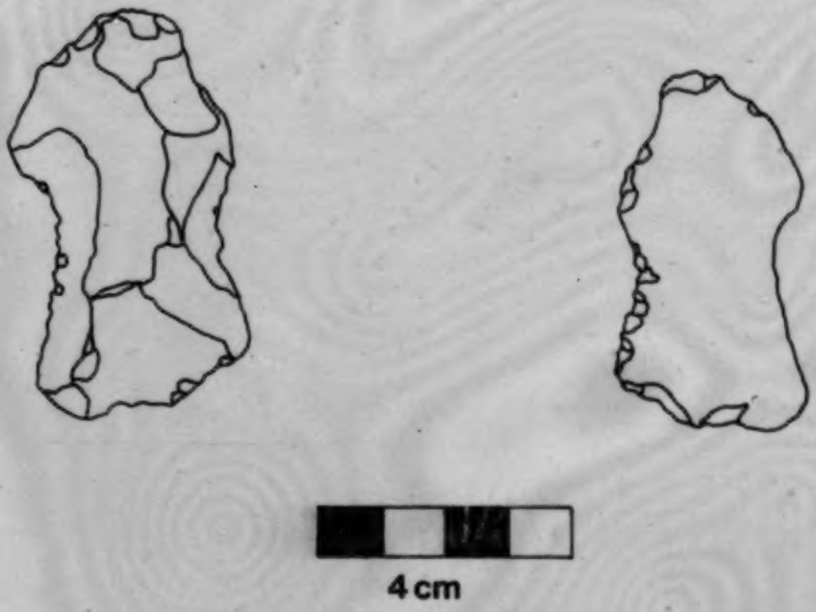


Figure 16. Small flake with edge microflaking.

V. The Caribou Island Site

A. Introduction

The Caribou Island site (GbOs 100) is located approximately 30 km west of the town of Bonnyville, adjacent to Moose Lake (approximately one km northeast), in east-central Alberta (Figure 17). The site occupies what can be described as a small "island", formed by dune sands blanketing a glacial kame. The "island" is in the midst of an extensive bog which is the remnant of a former channel that drained Moose Lake before the outlet was diverted to the north by differential isostatic rebound (Bryan and Bonnichsen n.d.).

Archaeological materials, including bipolarly-split quartzite cobbles and chert pebbles, flakes and bifaces occur in the dune sands, which vary in thickness from 50 cm to several meters, and in the underlying discontinuous gravel stratum (Figure 18). The gravel stratum is composed primarily of quartzite cobbles and pebbles in a sand matrix. The artifact-bearing layers overlie a clay till core containing pockets of sorted quartzite gravels. From the vast quantity of cores and debitage, it appears that prehistoric peoples visited this locale over several millennia for the purpose of extracting raw materials for stone tool production.

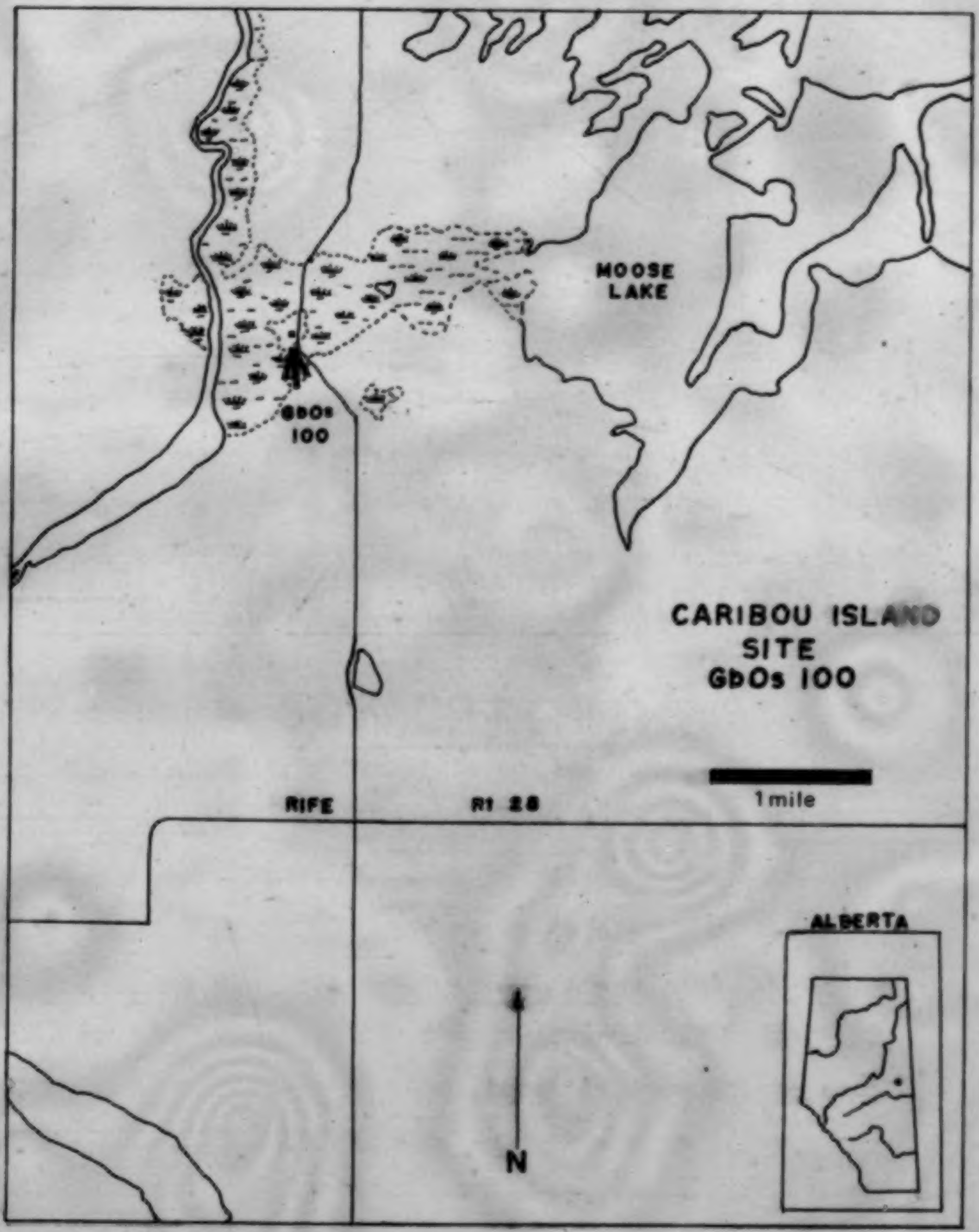
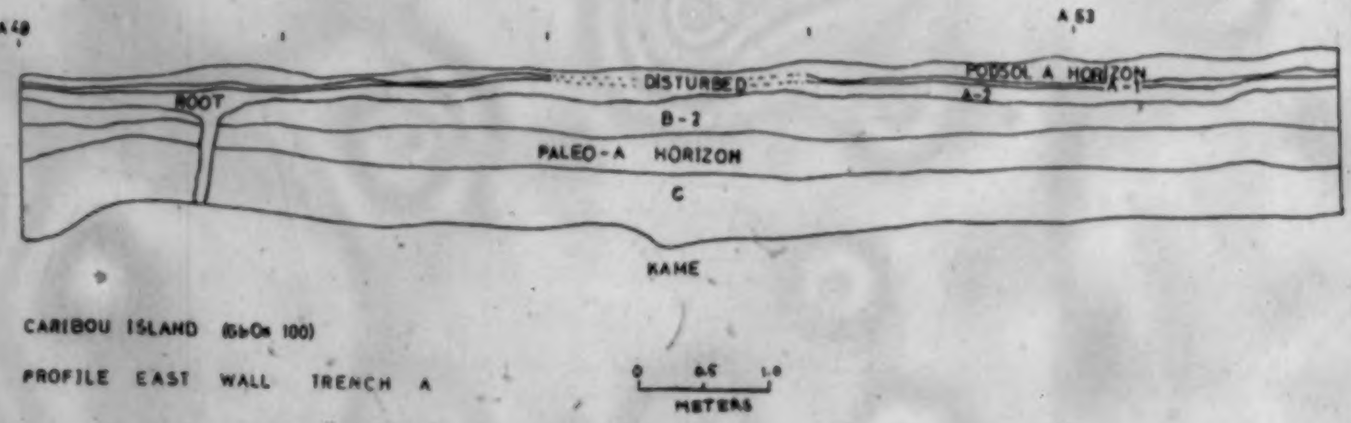
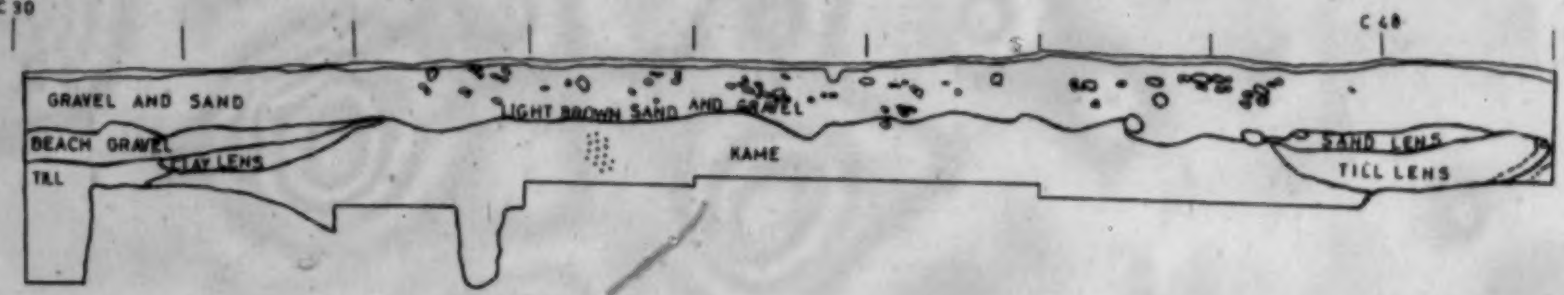

MOOSE
LAKE
GbOs
100
CARIBOU ISLAND
SITE
GbOs 100
1 mile
RIFE
Rt 28
ALBERTA
N

Figure 17. Location of Caribou Island site (GbOs 100).


A 48
A 53
POUSOL A HORIZON
A-1
A-2
DISTURBED
ROOT
B-2
PALEO-A HORIZON
C
KAME
0
0.5
1.0
METERS

CARIBOU ISLAND (GbOs 100)

PROFILE EAST WALL TRENCH A


C 30
C 48
GRAVEL AND SAND
BEACH GRAVEL
CLAY LENS
TILL
LIGHT BROWN SAND AND GRAVEL
KAME
SAND LENS
TILL LENS

CARIBOU ISLAND (GbOs 100)

PROFILE EAST WALL TRENCH B

0 0.5 1.0

METERS

▨ STRATIFIED SAND

Figure 18. Caribou Island site profiles (1965 excavations: from Bryan and Bonnichsen n.d.).

B. The Problem

During the initial excavations under the direction of Alan Bryan in 1965, test explorations were extended in several units to some depth into both of the gravel strata underlying the dune sands. These excavations exposed numerous fractured cobbles, a small percentage of which in the lower kame gravels obviously had been fractured in place. Amongst these fractured gravels, occasional specimens were recovered that resembled unifacial tools. Throughout these deeper gravels Bryan noted the conspicuous absence of bifacial implements or debitage from their manufacure. From these initial observations, three questions were posed: 1) how could one distinguish artifacts in the upper gravels from the naturally-fractured cobbles and pebbles which could have been introduced from below, 2) what mechanism(s) could account for the presence of such a great quantity of fractured clasts in the upper gravels, and, 3) if there are artifacts in the deeper gravels, what mechanism could account for their presence?

Before considering the question of distinguishing naturally from humanly-flaked stone in this context it is necessary to review pertinent observations of fracturing of gravel beds elsewhere in the prairie provinces.

C. Fracture Mechanisms

Initially, the hypothesis was entertained that broken cobbles and pebbles in the gravel strata had been fractured by the action of lake ice ramparting surficial sediments and exerting great pressure on gravels in a frozen matrix (Bryan and Bonnichsen n.d.). This mechanism would have necessitated the existence of a formerly more extensive Moose Lake, possibly a pro-glacial lake resulting from the damming of former outlet drainages. It was felt that an ice rampart mechanism as well as simple beach action might account for both the fracturing of clasts and their mixing with artifacts in the upper gravels. In addition, this hypothesis also provided a means for relative age estimation by tying in mixing of the artifacts with late glacial events.

The hypothesis of ice rampart action as the agent responsible for fracturing of clasts and mixing of deposits seems, at present, unacceptable for several reasons. In the first place, there is no independent evidence for the existence of a more extensive lake in the form of strandlines or lacustrine sediments. Cores taken adjacent to the "island" and nearby in the bog reached clay-till (the intervening sediments consisted of well-sorted sand, probably aeolian in origin) without encountering evidence for lacustrine sediments. More importantly, it must be seriously questioned whether ice-ramparting is competent to fracture large pebbles and cobbles on the scale that is observed in the gravels at the site. Generally, ice-rampart activity results in the plowing up of the surface beach sediments, thereby forming the rampart feature. Unless specimens were frozen tightly in the underlying matrix, the gravels would give before failure occurred. Most of the in situ fractured specimens were recovered from the loose sands and gravels overlying the kame and would not be expected to be frozen in place due to their high porosity (assuming adequate drainage). In addition, evidence of a rampart feature was not detectable in any of the lateral or sagittal profiles.

The improbability of ice-ramparting as a fracture mechanism was further confirmed by excavations in 1980 near the highest elevation of the kame core of the island. These excavations revealed a somewhat similar stratigraphic situation to that described for the presumed beach area. Test units sunk through dune sands into the sorted gravels revealed numerous disturbed and in situ fractured clasts, as in the previous excavations. Thus, ice-ramparting, unless it affected the entire "island," is unlikely to have caused the large scale fracturing of quartzite gravels observed at the site. However, no possible artifacts were recovered during these excavations.

Thus, the ice rampart hypothesis is unacceptable as a mechanism for the fracture of the gravels at the site but may conceivably be responsible in part for the mixing of specimens in the loose gravels at lower elevations. This latter possiblity is, however, unsubstantiated by by independent lines of evidence at present.

D. Ice-Thrust Fracture of Gravels

An alternative mechanism for the in situ fracture of the quartzite gravels has been suggested by the work of Babcock, et al. (1978) and Kupsch (1965) who have studied large scale fracturing of gravel beds in the prairie provinces. These authors describe gravel pit exposures in Alberta (Babcock, et al. 1978) and Saskatchewan (Kupsch 1965) of Tertiary quartzite gravels that are characterized by varying degrees of deformation of beds and intensity of clast fracture and/or pulverization.

At several localities the responsible fracture mechanism, glacial ice thrust, can be independently verified by the presence of extensive faulting and deformation of the beds. At other localities, where independent lines of evidence do not exist, the ratio of fractured clasts to unfractured clasts was used to identify an ice-thrust mechanism. This latter interpretation is based on comparisons with gravel pits unaffected by ice-thrust (Babcock, et al. 1978).

The general fracture mechanism envisioned at these localities is that of clast on clast impingement by a network of medium-sized (4-6cm) and larger gravels bearing the weight of an overriding continental ice mass. Factors believed to be responsible for varying degrees of fracture intensity include variations in the clay-sized fraction in the matrix and resultant variation in pore water pressures between beds (Babcock, et al. 1978).

Several of the beds described contain completely pulverized quartzite clasts while in others, clasts were less intensely fractured. In these more moderately fractured beds, clasts were described as exhibiting one or more fractures radiating out from the point of impingement with one or more neighboring clasts.

The relevance of ice-thrust fracture to the explanation of the presence and condition of the gravel bed at the Caribou Island site is somewhat problematic at present. Some similar mechanism would seem to be called for in order to explain quartzite gravel beds where approximately 50% of the clasts larger than 3 cm are fractured. However, of these fractured clasts only approximately 5% exhibit evidence of having been fractured in place; the remaining fractured clasts could not be "mated" with the other portions of the original clasts at Caribou Island.

Presumably, the gravels making up the gravel bed at the Caribou Island site could have been initially fractured elsewhere and the gravels subsequently transported to their present location. According to Mark Fenton of the Geological Survey of Alberta (1980: pers. comm.), these gravels must have been transported from elsewhere to their present location, as intact deposits of Tertiary gravels in this area are characteristically buried under up to several hundred feet of till. If this is indeed the case then the intact fractured clasts may represent either a subsequent fracture episode of much more moderate intensity, or possibly clasts transported in a frozen state that managed to retain their respective mates.

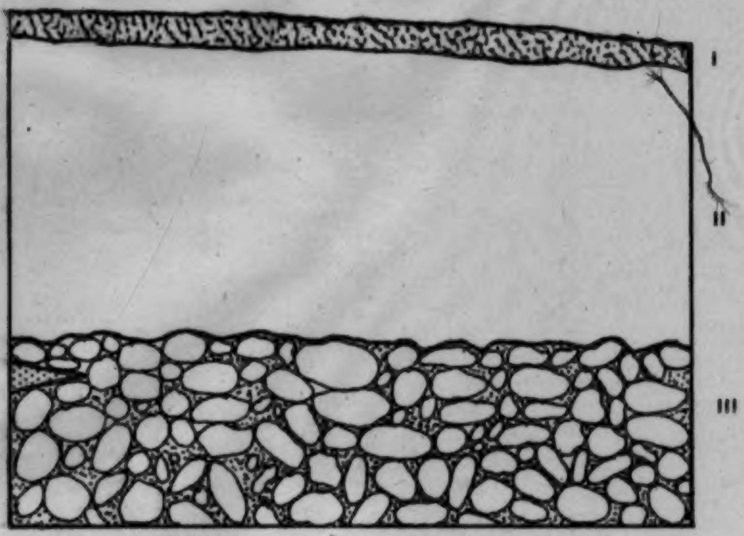
E. Description and Context of Specimens

The majority of specimens recovered from the lower dune sands and upper loose gravels consist of fractured quartzite clasts with less frequent fractured chert pebbles. Most of the specimens are debitage from stone tool production, including flakes and spalls, longitudinally-split cobbles and pebbles, anvilstones, and a few bifacially and unifacially worked tools.

The location of the site above a good supply of flakeable quartzite and chert clasts, and the low tool to debitage ratio suggests that a major activity for aboriginal peoples at this location was the production of stone tools. Towards the southern, downslope area of the excavated portion of the site the cover of sand over the gravels is comparatively thin, between .75 and 1 m. Moving northward and upslope the dune sand cover attains a depth of more than two meters in some places (Figure 19). This difference in thickness of the sand cover probably in part accounts for the greater intensity of debitage towards the southern portion of the site; the greater thickness of sand obscuring the presence of raw materials below.

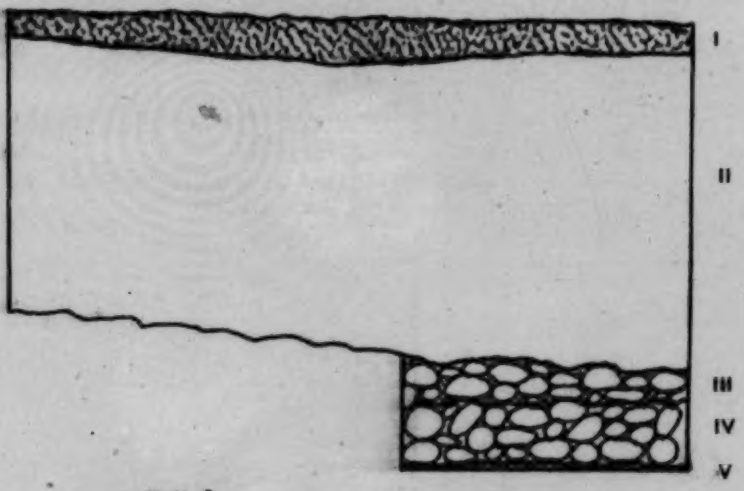
Figure 19. Profiles from 1980 excavations. Pits located on crest of "island."
Stratum I=Modern soil.
Stratum II=Dune sands and artifacts.
Stratum III=Loose sand and quartzite gravels (no possible artifacts).
Stratum IV=Compact sand and quartzite gravels (no possible artifacts).
Stratum V=Clay with gravels (kame).

W Wall

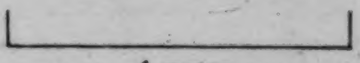


Unit 1

S Wall



Unit 3



The 1980 excavations near the crest of the hill revealed a sharp contrast between the dune sands and the underlying sorted gravel bed (i.e., the loose sand and gravel unit was not present). Occasional artifacts were recovered throughout the dune sands to the contact between sand and gravel. On the surface of the gravel bed several longitudinally-split quartzite cobbles with shatter (angular by-products of quartzite cobble splitting) were exposed. These specimens indicate that prehistoric hominids were present and utilized the available raw materials before the gravels were covered by sand.

Excavations were extended down thru the gravel bed revealing numerous fractured quartzite cobbles. Six were apparently fractured in place. However, no possible artifacts were located.[1]

Most split cobbles within the gravel stratum exhibited single or multiple fractures that bisect the specimen on a plane perpendicular to the longitudinal axis. A smaller number of specimens had one or more spalls removed (see discussion of spalling versus flaking later in this chapter).

Excavations during the 1965 field season revealed a somewhat different stratigraphic situation on the southern portion of the site. In this area there were three distinct strata: the overlying sand, a stratum with quartzite and chert pebbles mixed in a loose sand matrix, and an underlying compact sorted gravel and sand deposit. Within the transitional unit, numerous artifacts were recovered. However, no in-place fractured clasts were encountered, these specimens being limited to the underlying sorted gravels.

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[1] Possible artifacts included longitudinally split or flaked quartzite clasts as discussed later in this chapter. Neither of these categories of fractured clasts were recovered during the 1980 excavations

Prior to 1980, Bryan worked with the hypothesis that the loose gravels in this northern, downslope portion of the site were beach gravels. The mixing of sands and gravels was explained by wave and ice-ramparting action. Given the results from testing on the crest of the site, (and the lack of independent evidence for an extensive lake), the alternative hypothesis is presented that human beings are responsible for the observed mixing in this portion of the site. People digging for flakeable stones could have mixed the gravels with the blanket of dune sand. The lack of "diagnostic" projectile points and other tools in this stratum noted by Bryan and Bonnichsen (n.d.) may simply be due to their low frequency elsewhere in the site deposits.

F. Naturally Fractured Clasts in the Gravels

The discussion of naturally fractured clasts involves primarily the in-situ fractured specimens as only these can be considered natural in origin with a high degree of confidence.

Idealized Fracture Types

Three fracture types can be distinguished by the direction of force loading relative to the axis of the specimens (longitudinal and transverse) and the placement of the impact point (leading to spalling versus splitting). These fracture types are idealized in the sense that they represent end-members with considerable variation between these extremes. The clasts within the gravel stratum are not uniformly oriented and thus points of contact are more or less randomly distributed along the surfaces of the specimens.

Transverse Splitting

Transverse splitting is by far the dominant mode of fracture in the gravel stratum. Specimens exhibiting transverse-splitting were failed by pressure roughly perpendicular to maximum width and length dimensions and parallel to the thickness dimension (Figure 20). The end-product(s) of this type of fracture were either two halves or three or more sections with steep angles between the dorsal and ventral surfaces.

Approximately 80% of the unmated specimens recovered from the gravel stratum exhibit this fracture type. Specimens fractured into three or more sections exhibit a single point of loading. Flake features such as ridges and proximal concavities are lacking on every specimen.

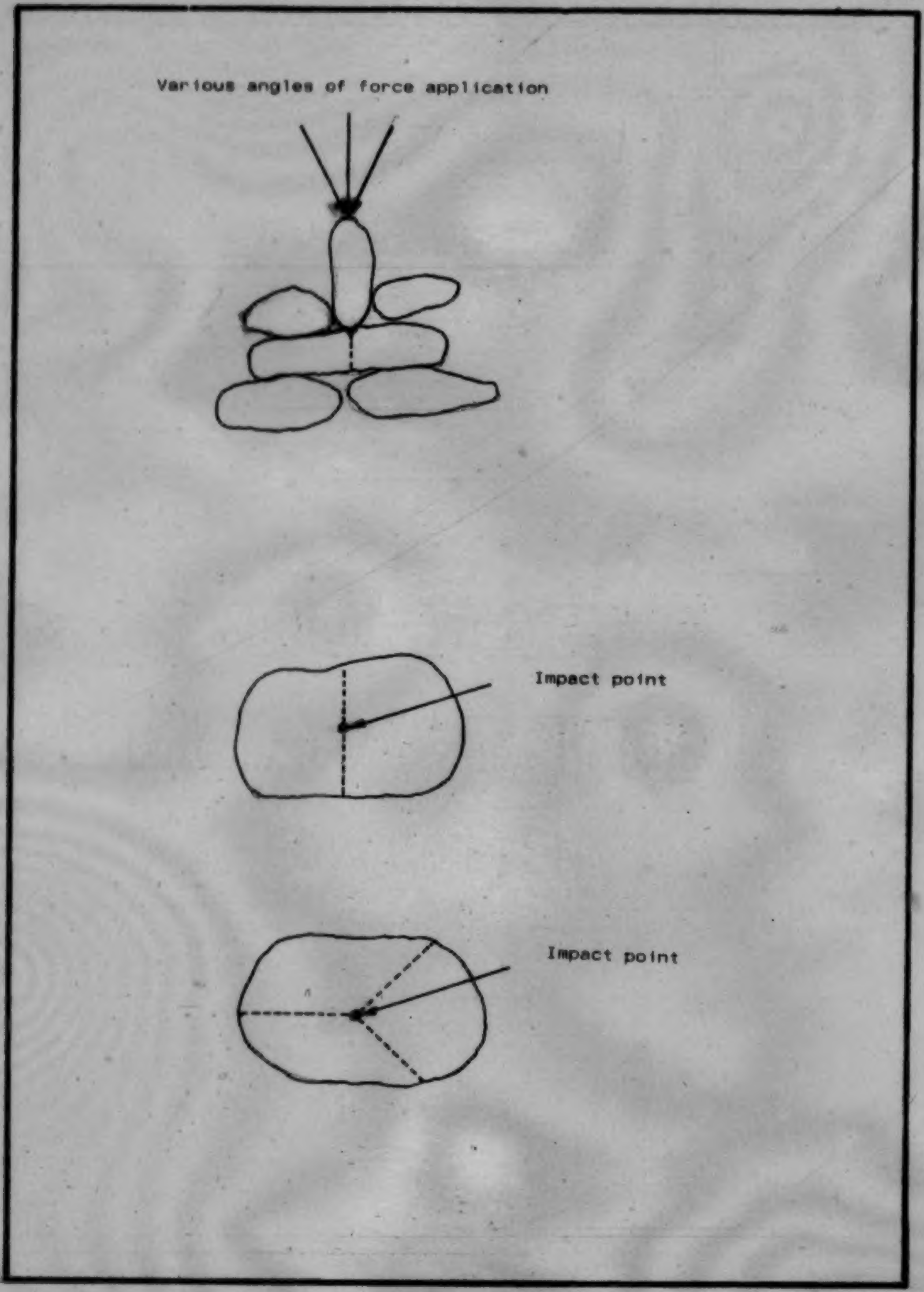
Various angles of force application
Impact point
Impact point

Figure 20. Transverse splitting of quartzite cobbles.

In percussive experiments carried out by the author, identical clast morphologies were obtained. In these experiments quartzite clasts with oval cross-sections were placed on anvilstones and fractured transversely by throwing a large hammerstone onto the specimen. It appears that clasts with more rounded cross-sections tend to fracture into multiple fragments, whereas specimens with more oval cross-sections tend to fracture into only two sections. These experiments indicate that transverse splitting by percussion produces similar features to pressure loading. Thus, specimens latitudinally fractured by humans would be identical to those fractured by the pressure of overriding ice.

Longitudinal Splitting

Longitudinal splitting occurs when loading took place parallel to the long axis of the specimen (Figure 21). This type of fracture is rare in the gravel stratum. Longitudinal splitting can lead to either single or multiple fracture products (Chapter 3). As discussed in Chapter 3, this mode of fracture is characteristic of human strategies for the reduction of quartzite cobbles.

Spalling

Spalling consists of the removal of small (relative to the parent clast) fragments from an edge or surface of a nodule. Four examples of this fracture type were observed in

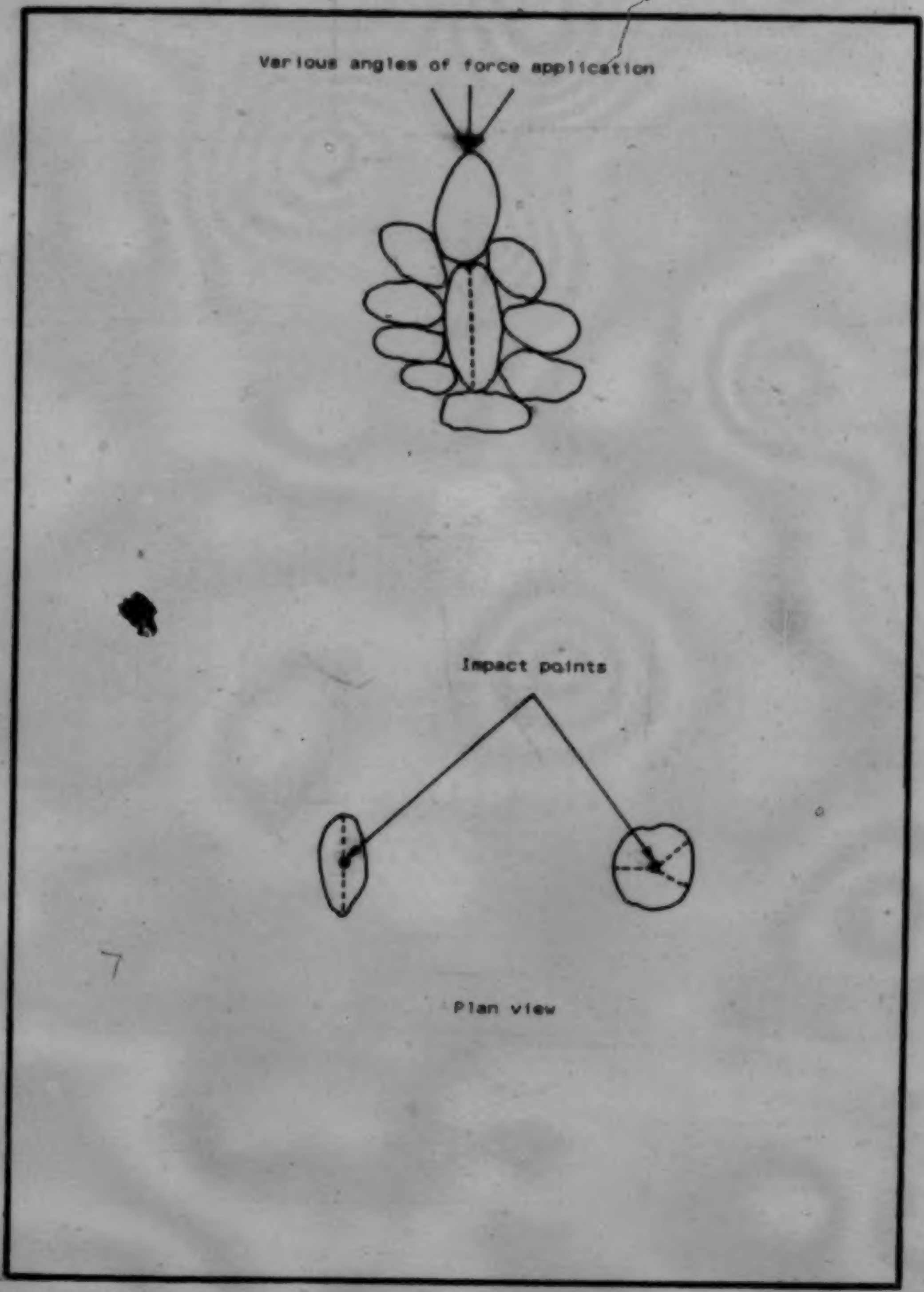
Various angles of force application
Impact points
Plan view

Figure 21. Longitudinal splitting of quartzite cobbles.

the sample of in-situ fractured specimens. This type of fracture simulates human hand-held percussion flaking or incomplete bipolar fracture. Spalling results in a scar on the parent clast similar to a flake scar.

Morphological features such as a bulb of percussion, ribs and hackles were not evident on the specimens in the sample. This fact probably relates to the coarse fracture typical of quartzite. The presence of a platform appears to depend on the placement of the point of impact on the parent nodule. If loading occurs adjacent to an angular corner a platform will be produced. If the fracture initiates from a smooth surface the platform will be absent (Figure 22).

Impact Points

An examination of impact points on naturally fractured specimens was made in order to determine if they systematically differed from experimentally percussion fractured specimens. However, on the basis of this qualitative examination it was impossible to detect significant differences. There may be a slight tendency for percussion splitting to produce slightly larger impact areas with greater damage to the proximal portion, but these tendencies are not great enough to be useful as a comparative attribute.

Discussion

Transverse splitting was found to be by far the dominant fracture type both in the collection of specimens

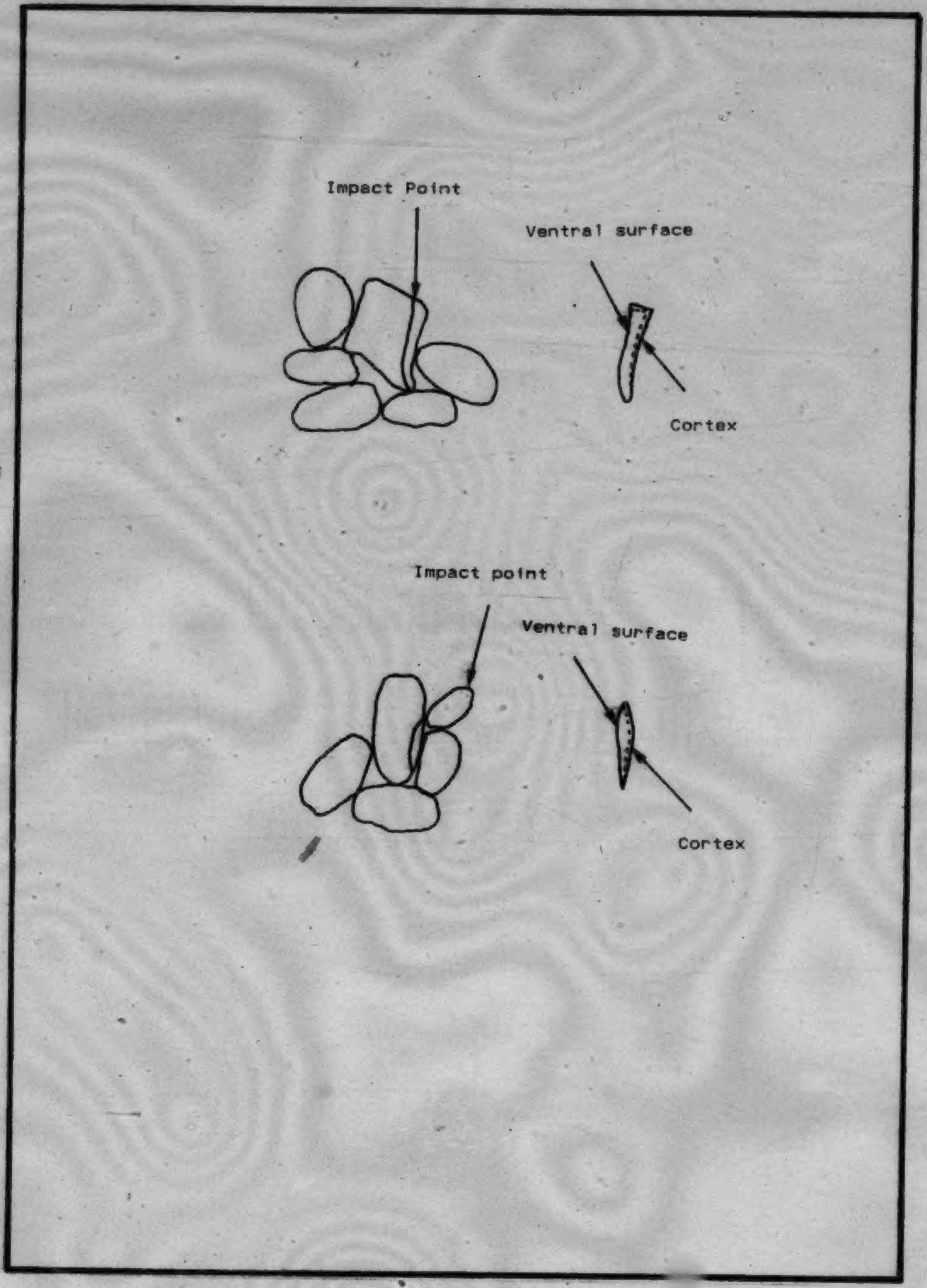
Impact Point
Ventral surface
Cortex
Impact point
Ventral surface
Cortex

Figure 22. Spalling of quartzite cobbles.

fractured in place and in the unmated specimens from the gravel stratum. Longitudinal splitting, characteristic of human stoneworking strategies, was rare. Pressure removal of spalls was also of limited frequency.

The reasons behind the low frequency of the latter two fracture types probably relates to two factors, 1) the orientation of clasts in the gravel stratum, and 2) the placement of impact points on specimens.

Clasts within the gravel stratum currently exhibit no preferential orientation. Whether or not this situation was true in the original deposits from which the gravels were derived is impossible to determine. If they were preferentially oriented it is probable that long axes were more or less parallel to the ground surface and, hence, perpendicular to the usual direction of force application (in a situation of glacial ice override). There may have been a degree of imbrication to the clasts as well.

Given either of the situations described above it is argued that transversely-split cobbles and pebbles would be the most probable end-products. In latitudinal splitting impact areas occur on the only slightly rounded surface of greatest available area. Thus the opportunity for stress to be accommodated by slippage versus failure is reduced. In longitudinal splitting the point of force application must occur on the extreme ends of the longitudinal axis. These ends possess a very much higher radius of curvature and therefore permit only a very small area for fracture initiation. In this situation, it would be very easy to accommodate stress by only very minimal movement by either the impacted clast or its impactor.

Personal attempts to split quartzite cobbles longitudinally reinforce this conclusion. In this case oval cross-sectioned cobbles were buried in sand with one point in contact with a buried anvilstone. Great care and precision was required to fail the specimens longitudinally. In many instances the impactor did not strike squarely on the exposed end of the buried cobble and only a glancing blow was struck. In other instances the impacted cobble accommodated stress by slipping sideways on the anvilstone.

Similar observations are pertinent to the pressure removal of spalls from quartzite cobbles. Angular specimens are rare in the gravels, thus precluding significant removal of spalls from angular surfaces. In addition, the probability of proper placement of an impactor just back from the corner of an angular surface is sufficiently low to render this an unlikely fracture type in beds of largely rounded cobbles. The low frequency of spall removal from smooth surfaces is related to the narrow range of conditions required for this type of removal. In this instance the angle of impact must be somewhat less than 90 degrees or latitudinal splitting will result. However, if the angle becomes too acute, the impactor would be expected to slide across the surface rather than resulting in spall removal.

G. Possible Artifacts in the Lower Gravels

All of the specimens believed to be artifacts recovered from the compact gravel stratum consist of unifacially altered or split quartzite cobbles and chert pebbles. The discussion below will focus on fracture types within this collection.

Transverse Split

The majority of specimens Bryan and Bonnichsen (n.d.) selected as possible artifacts consist of transversely split clasts. Most of these specimens do not possess steep, nearly perpendicular fracture faces characteristic of most of the naturally fractured specimens (due to field selection procedures). Instead, the fracture face is somehwat acute, giving the impression that the clasts is a unifacially flaked chopping tool. On specimens from which three or more fragments were removed, a curved edge was produced simulating unifacial flaking even more closely. In addition, several specimens possess a bit-like edge. This relatively rare feature was probably caused by a lack of solid support on the side opposite the point of force application. Similar experimental results were obtained with percussive fracture (although this was a rare product).

The specimens described above simulate unifacially flaked quartzite cobbles. Recognition of transverse splitting as the fracture process necessitated examination of the point of force application. If the PFA is located on the face opposite the 'edge,' latitudinal splitting was inferred. If the face was created by hand-held percussion flaking the PFA would have had to have been located on the 'edge' (Figure 23). The author's experiments have shown that identical fracture products can be produced by percussive splitting of properly oriented quartzite cobbles. However, this type of fracture is rare in humanly-flaked collections.

Longitudinal Splitting

A few specimens collected from the lower gravels exhibit longitudinal splitting. These specimens resemble humanly-split specimens from the dune deposits in every way and thus cannot be distinguished from them.

Spalling

A few specimens exhibit spalled surfaces or edges. The majority of these specimens exhibit only a single spall removal. Where the spall was removed from a surface, as oppossed to an edge, it is probably safe to infer a natural origin due to the difficulty of flaking obtuse quartzite surfaces by hand-held percussion. Edge-spalled surfaces are distinguished with greater difficulty.

A very small number of specimens exhibit unidirectional flake scars originating from an edge. The scars are usually unidirectional, unifacial and exhibit morphological features similar to unifacially-flaked artifacts from the dune deposits. However, flaking is restricted to a single edge as opposed to two or more edges.

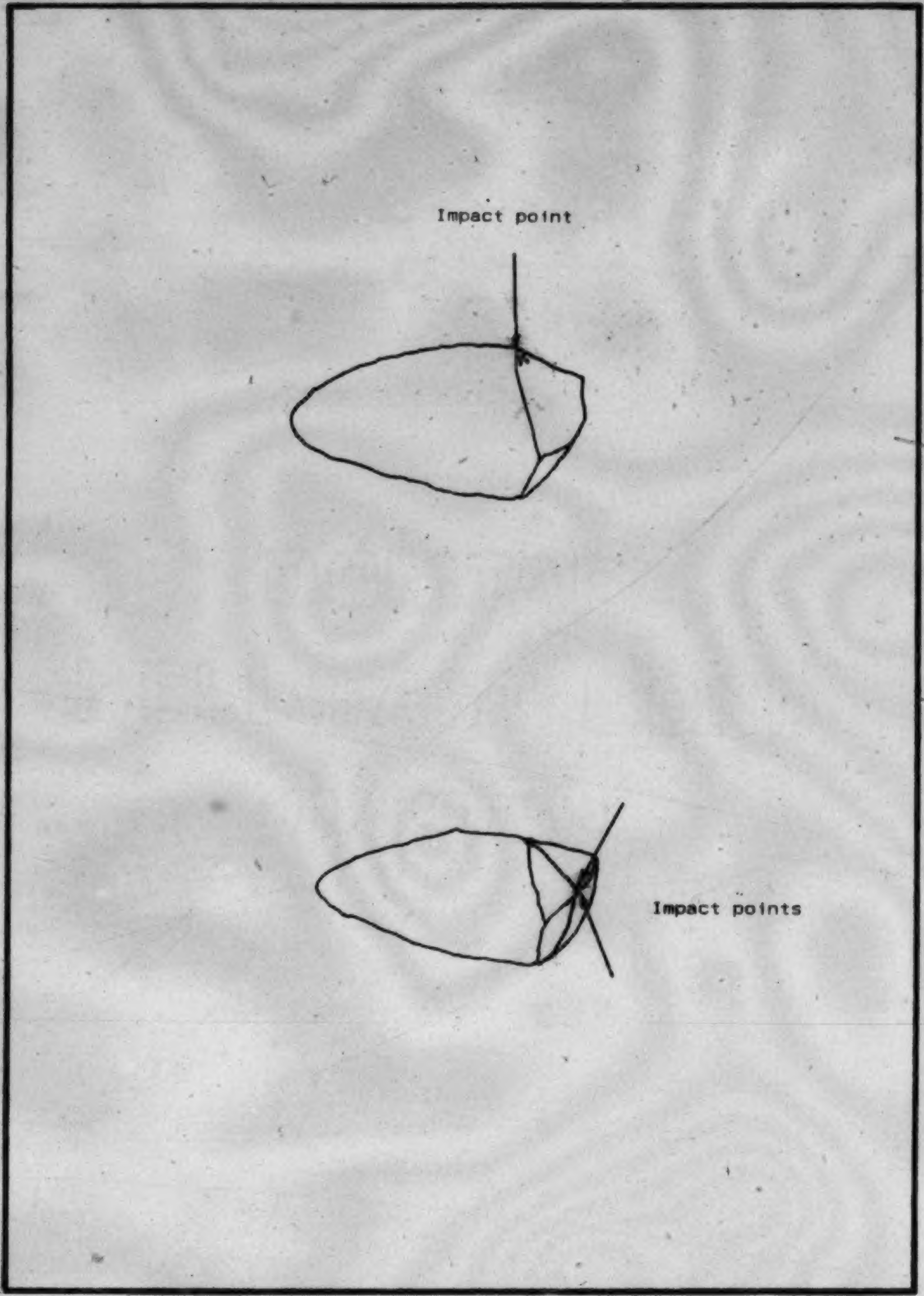
Impact point
Impact points

Figure 23. PFA's for transverse splitting and hand held percussion.

H. Assessment

In the preceding evaluations and discussion it was determined that flaked and split quartzite specimens from the lower gravels exhibit fracture types and morphological features which are exhibited on naturally fractured as well as on experimentally fractured specimens. However, the majority of fractured clasts in the lower gravels conform to the dominant natural fracture mode (i.e., transverse splitting). Further, this fracture type is uncharacteristic of the human alteration of quartzite cobbles. Transversely-split specimens are therefore determined to be of natural origin with a high degree of probability.

A few longitudinally-split specimens, characteristic of human alteration products and a rare fracture type in natural situations were also found in the lower gravels. Thus these specimens must be assessed by other parameters as well. The alternative possibilities are that they were fractured naturally or fractured by humans and incorporated into the lower gravels by human beings excavating for raw materials.

Some flaked specimens from the lower gravels resemble human alteration products. Similar examples, with two or more flakes removed were not found in the collection of definitely naturally spalled specimens. Thus, if these specimens are naturally flaked, they must represent one extreme of output morphology for this environment. Without a larger sample of flaked specimens it is difficult to evaluate their status with much confidence.

I. Conclusion

Although the assessment of the Caribou Island assemblage was not entirely conclusive with respect to the natural versus human status of every specimen, the analysis does provide important implications for archaeological research elsewhere in the glaciated prairie provinces. In addition, this study illustrates the utility of collected control specimens of known natural origin and the difficulties in assessing a very small population of specimens in light of natural processes characterized by extreme ranges in energy and output morphology.

The natural fracture of quartzite cobbles at the Caribou Island site may represent a widespread phenomenon in the prairie provinces. Babcock, et al. (1978) have described in-situ fracturing of quartzite gravels on a larger scale than observed at the Caribou Island site. If this natural fracture phenomenon is as widespread as indicated by previous studies, then the potential for misidentification of naturally-fractured specimens as artifacts in redeposited contexts may be large.

Without control samples of known naturally fractured quartzite clasts, it would have been very difficult to evaluate the range of expected natural fracture products. Without this knowledge, the assessment of the status of specimens would have been difficult and certainly inconclusive. As it was, the small number of specimens representing one morphological type (flaked specimens) were difficult to assess with confidence.

VI. The E.S.P Site

A. Introduction

The initial discovery and subsequent excavation of the E.S.P. site would make interesting reading in and of itself; however, a discussion of the history of this site is not directly pertinent to the present study. Interested readers are directed to Goodman (1978, 1981) for a discussion of the remote sensing strategy employed in locating this site.

The E.S.P. site is located at approximately 8000 feet in the San Francisco Peaks area (Little Mount Elden) near Flagstaff, Arizona (Figure 24). The site was initially excavated under the direction of Jeffrey Goodman (Goodman 1977) and later by Alan Bryan of the University of Alberta in 1979 (Bryan n.d.).

The E.S.P. site provides an ideal example of the "eolithic" problem. The site has yielded a collection of questionable artifacts above and below a layer dated by radiocarbon to ca. 24,000 years ago (25,470 ± 1700 BP [I-7519], 22,490 ± 420 BP.[2] In addition, the project geologist, Thor Karlstrom (U.S.G.S.), identified a paleosol beneath the dated stratum which may be Sangamon in age. Unfortunately, the proposed artifact sample is quite small, and is dwarfed by the presence of large numbers of angular, naturally-fractured chert clasts in the same deposits.

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[2] No range of error given in Goodman n.d.

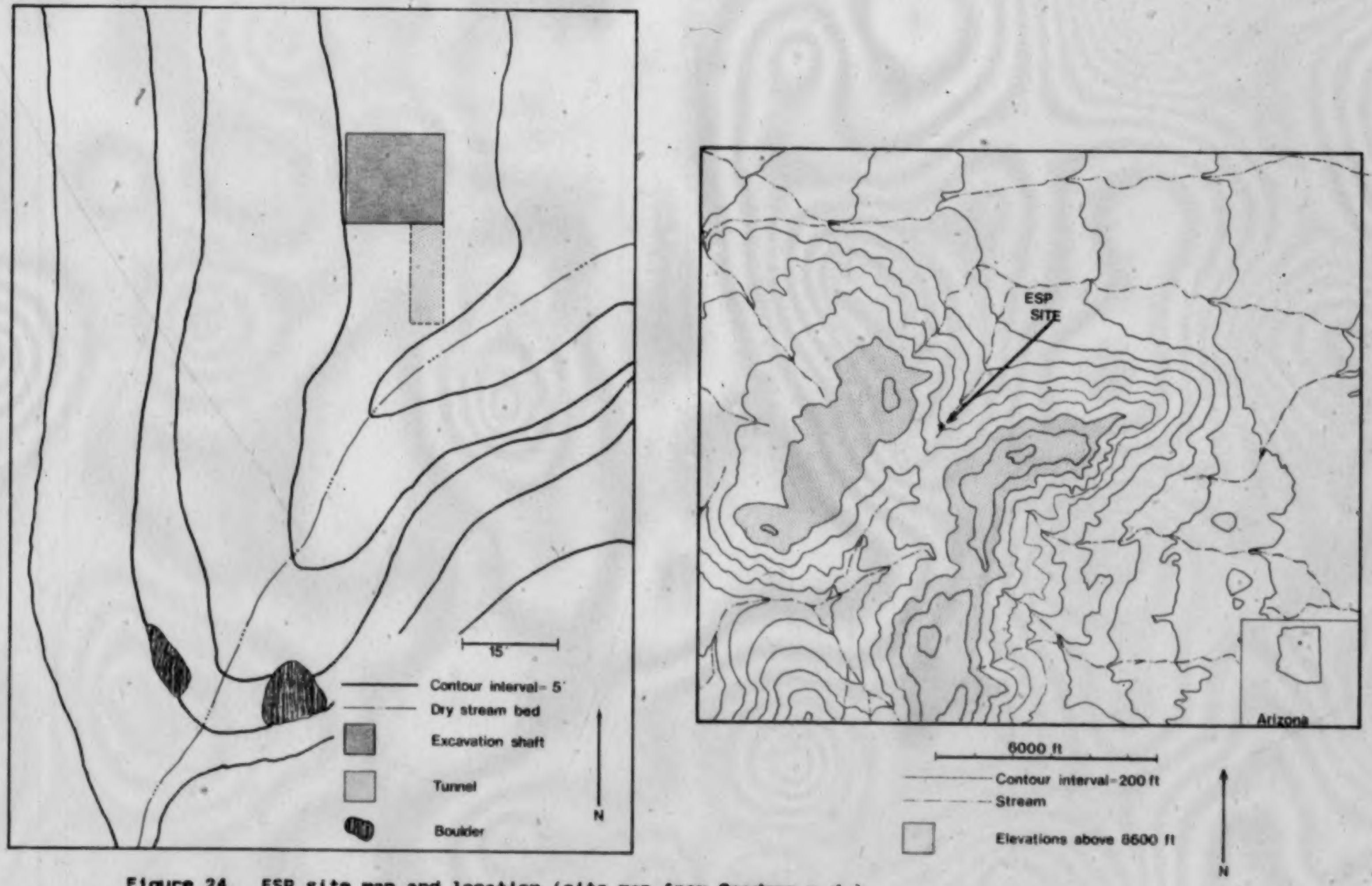
15'
Contour interval- 5'
Dry stream bed
Excavation shaft
Tunnel
Boulder
N
ESP SITE
Arizona
6000 ft
Contour interval-200 ft
Stream
Elevations above 8600 ft
N

Figure 24. ESP site map and location (site map from Goodman n.d.).

In addition to the small size of the sample of proposed artifacts, the study of this collection was cut short by the untimely interference of the U.S.National Forest Service which demanded return of the collection two weeks after the laboratory analysis had begun. Thus the discussion to follow is not as complete as would have been desired. Nevertheless, the site provides an example of the geomorphic environment of a talus slope.

B. Site Description

The excavation consists of a 10 foot by 10 foot shaft sunk in some places up to 34 feet into poorly stratified, coarse unsorted colluvial and alluvial sediments. During the 1979 excavations it proved impossible to examine the stratigraphic sections exposed by Goodman's excavations as the majority of the wall area had been reinforced with cribbing for safety reasons. Goodman's idealized stratigraphic cross-section is presented in Figure 25.

During the 1979 field season excavation was largely confined to a tunnel leading off to the south from the main vertical shaft. The sediments in this area were comprised of a sandy-silt matrix containing abundant clasts ranging from small pebbles to large, boulders. The predominant lithologies present in the gravel to boulder size classes are a green dacite, and a white chert.

The cherts recovered throughout the excavations are locally derived upslope from outcroppings of the Kaibab

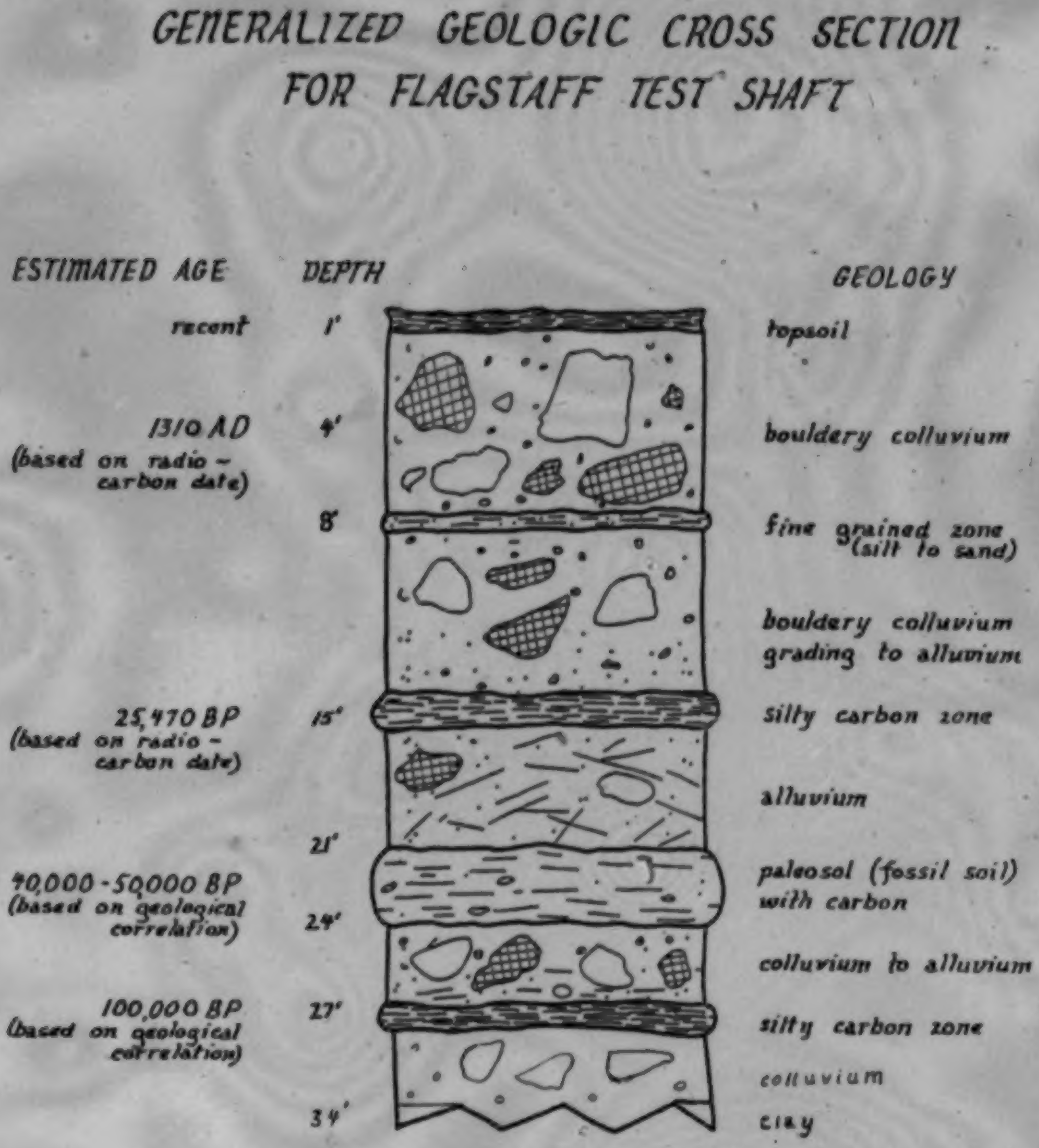
GENERALIZED GEOLOGIC CROSS SECTION FOR FLAGSTAFF TEST SHAFT
ESTIMATED AGE
DEPTH
GEOLOGY
recent
1'
topsoil
1310 AD (based on radio-carbon date)
4'
bouldery colluvium
8'
fine grained zone (silt to sand)
bouldery colluvium grading to alluvium
25,470 BP (based on radio-carbon date)
15'
silty carbon zone
alluvium
21'
40,000-50,000 BP (based on geological correlation)
paleosol (fossil soil) with carbon
24'
colluvium to alluvium
100,000 BP (based on geological correlation)
27'
silty carbon zone
colluvium
34'
clay

Figure 25. Idealized cross-section of ESP site (from Goodman n.d.).

limestone. Downslope from the outcrops, the talus is littered with abundant chert clasts, occasionally containing evidence of human activity in the form of broken bifaces and flakes.

Excavation Methodology

Throughout Goodman's initial excavation, tools included jack-hammers, picks, and dynamite where necessary. For the majority of the time shovels and hammers were employed.

Goodman (n.d.) states that the initial excavation procedures involved following the 'levels' predicted by a "psychic". All material recovered was screened through 1/4" mesh screen. Only specimens felt to be artifacts were saved.

During the 1979 field season excavation consisted of removing one foot deep and one foot thick arbitrary levels the width of the tunnel. Again, all material was screened through a 1/4" mesh. In addition, all chert materials were saved for comparative purposes.

C. Description and Location of Specimens

The E.S.P. site collection consists of 22 complete flakes, several flake fragments, numerous spalls, and several specimens exhibiting possible edge-wear and/or retouch. These specimens range in distribution from the surface down to approximately 27 feet in depth. Due to the excavation procedures employed, specimens can only be vertically relocated within a two foot to as much as a three foot thick excavation level. However, it is possible to place specimens into Goodman's idealized cross-section in at least gross terms.

The greatest frequency of technical flakes[3] come from the bouldery colluvium between one to eight feet in depth. Three other technical flakes fall somewhere between seven to twelve feet in depth and thus cannot be safely located in terms of Goodman's profile. A radiocarbon date of 750 years (I-8564: no range of error given by Goodman) was obtained from charred wood between four to five feet in depth (Goodman n.d.).

One technical flake can be confidently located in the bouldery colluvium between 8 and 15 feet in depth. The dates of 25, 470 + 1700 BP and 22,400 + 420 BP on charcoal collected from the silty carbon zone at 15 feet provide a maximum age for this specimen.

Four technical flakes were recovered between 15 and 21 feet in depth. These specimens overlie the paleosol between 21 and 25 feet in depth. No technical flakes were recovered from the paleosol and it is impossible to tell whether specimens the four specimens were initially located at its surface.

Finally, three technical flakes were recovered between 24 and 27 feet in depth, below the paleosol and above the lowest silty carbon zone identified by Goodman at 27 feet.

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[3] 'Technical flake' refers to stone clasts exhibiting morphological features characteristic of stone flakes in human assemblages

The numerous chert spalls, angular clasts and minimally altered basalt and chert objects were recovered at various depths throughout the section. The depths of these specimens will be discussed where pertinent.

All of the flaked specimens are of white to pale yellow chert, which is represented on the surface as spalls, flakes, and nodules. From a flintknappers perspective the quality of this chert is rather poor. Most nodules contain abundant internal flaws that cause them frequently to shatter into angular spalls rather than producing flakes. However, broken bifaces and flakes present on the surfaces of the slope attest to the fact that aboriginal craftsmen occasionally did make use of this raw material.

D. Natural Processes

Whether or not the specimens from this site are in fact artifacts, it is clear that the bulk of other chert clasts in the deposits were fractured and transported by several geomorphic processes (Figure 26). Initial disaggregation of chert from the outcropping high on the talus slope resulted from a variety of physical weathering processes, including freeze-thaw fracture, root pressure, and residual stress release. The products of these processes are angular fragments, angular nodules and frost spalls.

During transport down the steep talus slope from the chert outcrops to the excavation unit, chert clasts probably were subjected to periodic percussion, as well as continuing

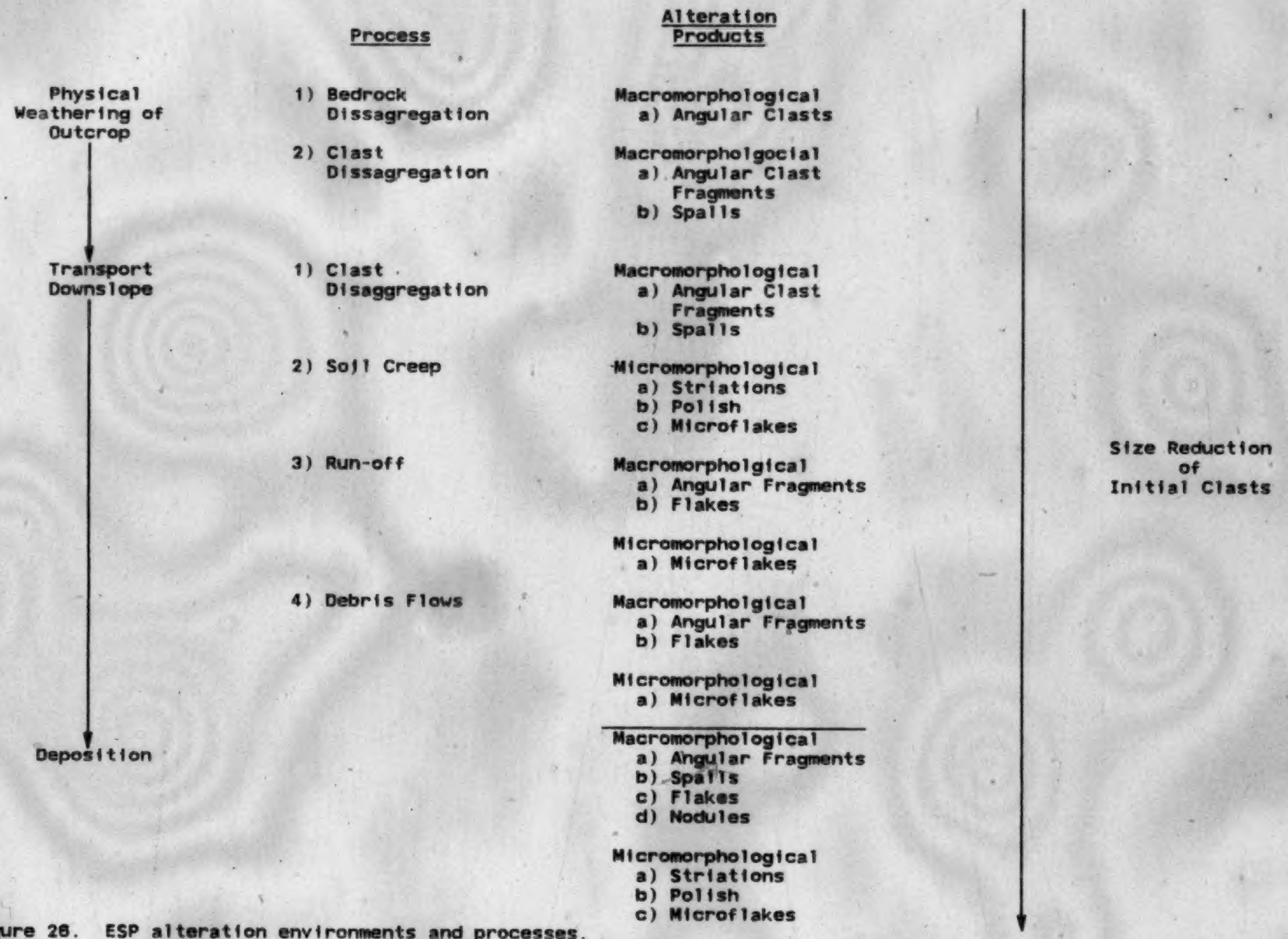

Process
Alteration Products
Physical Weathering of Outcrop
1) Bedrock Dissagregation
Macromorphological
a) Angular Clasts
2) Clast Dissagregation
Macromorpholgocial
a) Angular Clast Fragments
b) Spalls
Transport Downslope
1) Clast Disaggregation
Macromorphological
a) Angular Clast Fragments
b) Spalls
2) Soil Creep
Micromorphological
a) Striations
b) Polish
c) Microflakes
3) Run-off
Macromorpholgical
a) Angular Fragments
b) Flakes
Micromorphological
a) Microflakes
4) Debris Flows
Macromorpholgical
a) Angular Fragments
b) Flakes
Micromorphological
a) Microflakes
Deposition
Macromorphological
a) Angular Fragments
b) Spalls
c) Flakes
d) Nodules
Micromorphological
a) Striations
b) Polish
c) Microflakes
Size Reduction of Initial Clasts

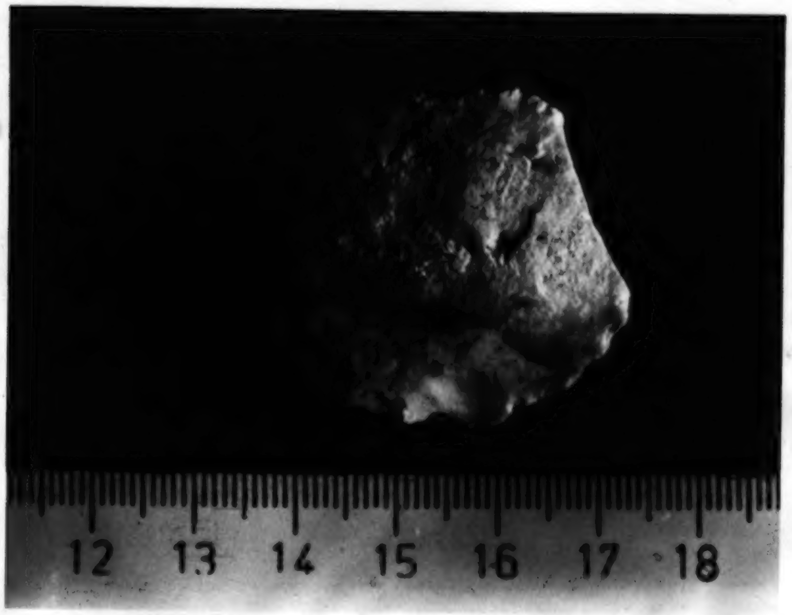
Figure 26. ESP alteration environments and processes.

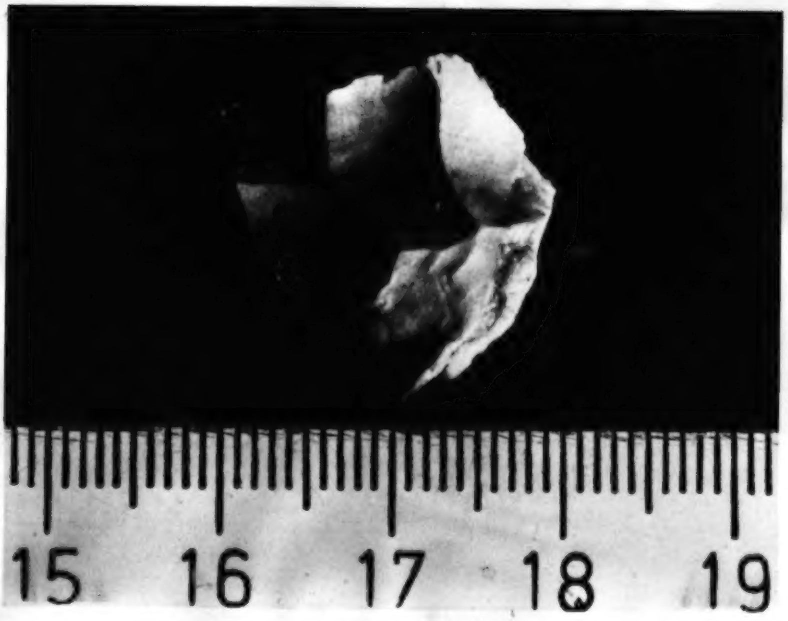
physical weathering processes. Movement of clasts downslope probably took the form of rolling of individual particles for short distances simply by gravity, or in connection with sheet and gully wash. In addition, at least some catastrophic events (land-slides) probably took place during the build-up of the sedimentary deposits as evidenced by the boulder field adjacent to the site and the numerous large boulders in the site deposits. The first of these transport mechanisms would be expected to lead to micromorphological alterations to edges and, less commonly, ridges of angular clasts. During occasions of catastrophic transport, a certain amount of macromorphological alterations would be expected.

E. Macro-Alterations

The majority of clasts present in the deposits and on the modern slopes consist of angular, polyhedral clasts resulting from the physical and chemical weathering processes outlined above. In addition, a number of frost spalls were identified in the proposed artifact sample. Frost spalls are easily identified on the basis of concentric rings originating from the center of the ventral surface (Oakley 1972: 9-11), feather terminations around the entire perimeter of the spall (i.e., no proximal portion), negative "nipples" (Pei 1939:), and the absence of diagnostic flake features (Plate 7). In several cases, it was possible to observe incipient frost spalls not yet fully

Plate 7. Frost spalls from the ESP site.


12
13
14
15
16
17
18


15
16
17
18
19

detached from the host nodule (Plate 8).

Although frost spalls are easily differentiated from flakes, thermal spall scars left on many parent nodules are difficult, if not impossible to distinguish from flake scars. In some instances frost spall scars are recognizable when positive nipples are present or, if the entire scar is visible, when the initiation point is lacking. If these clasts were more fine-grained, concentric ripples would also be a useful indicator of freeze-thaw spalling versus flaking. However, since the features outlined above are not observable on many specimens exhibiting scars, the question of whether or not specific scars on flakes or spalls are due to freeze-thaw spalling or percussion flaking is difficult to determine.

Excluding the obvious frost spalls and unmodified angular clasts, the remainder of the collection consists of the 22 complete technical flakes, six distal or proximal flake fragments, and several spalls with minimally damaged edges.

F. Micro-Alterations

A small number of spalls exhibit microflake scars on their edges and ridges. In the majority of cases these scars are isolated and randomly distributed around the edge perimeter. In a transport environment such as envisaged for the E.S.P. site deposits, these micro-alterations would be expected on at least a portion of the included clasts.

Plate 8. Incipient frost spall.

14
15
16
17
18

Certainly, there is no evidence for intentional shaping of edge perimeters. If the damage exhibited on these specimens is the result of human action, it was of a brief nature.

Two other clasts exhibit a more continuously damaged edge perimeter. The large clast illustrated in Plate 9 (depth=16-21 feet) exhibts 2 parallel unidirectional flake scars along a portion of one edge. Another specimen possesses a series of unifacial microflake scars along approximately 3.5 cm of its edge perimeter (Plate 10: depth=15-17 feet).

Of the sample of technical flakes, many specimens appear to be in a relatively "fresh" condition. Plate 11 illustrates one specimen, a thin, fragile flake recovered at a depth of approximately 27 feet. Clearly this specimen had not been subjected to a vigorous attritional environment during its transport from point of detachment to its final resting spot.

G. Technological Analysis

For purposes of this analysis, all flakes are initially considered as a single population. However,it should be kept in mind that specimens within this artificial population were recovered from the surface and at various depths within the site to approximately 27 feet.

Metric Descriptions

The majority of flakes recovered from the E.S.P. site are of medium size. Distributional data for weight, length,

Plate 9. Microflaked clast.

Plate 10. Microflaked clast.

17
18
19

Plate 11. Thin flake from the ESP site.

5
6
7
8

6
7
8

width and thickness are displayed in Table 32. Approximate flake surface data are given by the length x width index in Table 32.

Clearly the majority of flakes in the E.S.P. collection are not large flakes removed by extreme force. Rather, these specimens would have required only modest force for removal. Gross two-dimensional shape characteristics are given by the length/width index presented in Table 32. These data indicate a population of specimens that are generally at least as long as wide, with some specimens approaching the proportions of a blade.

Platform Angle

Distributional data for platform angle as a continuous level measure are presented in Table 32. As platform angle is largely determined by initial core face angles and force direction, these data indicate a rather high incidence of outward force vectors. These data reveal the absence of platform angles within expected ranges for biface thinning.

Proximal End Attributes

Descriptive statistics for platform depth and width are presented in Table 32. These statistics describe a population of platform dimensions that are of medium depth and width. In no instance is the PFA located exceedingly far from the edge, and in most cases the platform does not appear to have been isolated to any great degree.

Frequency data for platform surface attributes are presented in Tables 33 and 34. The majority (54%) of

Table 32

Metic Data for E.S.P. Flakes

	Mean	Std. Error	Std. Dev.	Variance	Kurtosis	Skewness	Range	Minimum	Maximum	# of Specimens
Weight	3.89	0.67	3.15	9.91	0.11	1.02	10.90	0.40	11.30	22
Length	2.64	0.21	0.94	0.89	0.37	0.75	3.80	1.10	4.90	22
Width	2.33	0.19	0.84	0.70	0.34	0.65	3.40	1.00	4.40	
Thick	0.53	0.05	0.22	0.05	0.68	0.46	0.70	0.20	0.90	22
Length x Width	5.57	0.90	4.23	17.92	0.52	0.80	16.17	0.00	16.17	22
Length/Width	0.98	0.11	0.51	0.26	-0.10	-0.67	1.70	0.00	1.70	22
Flaking Angle	76.19	3.34	15.30	234.06	-0.39	0.08	58.00	52.00	110.00	21
Platform Depth	0.38	0.05	0.22	0.05	2.50	1.49	0.90	0.10	1.00	20
Platform Width	1.23	0.23	0.57	0.32	0.77	0.82	2.20	0.50	2.70	20

Table 33

Platform Surface Morphology

Category Label	Absolute Freq	Relative Freq (Pct)	Adjusted Freq (Pct)	Cum Freq (Pct)
Cortex	12	54.5	70.6	70.6
1 Scar	3	13.6	17.6	88.2
2-3 Scars	1	4.5	5.9	94.1
Ground Surface	1	4.5	5.9	100.0
Indeterminate	5	22.7	Missing	100.0
Total	22	100.0	100.0	

Table 34

Platform Preparation Scars

Category Label	Absolute Freq	Relative Freq (Pct)	Adjusted Freq (Pct)	Cum Freq (Pct)
No Scars	5	22.7	22.7	22.7
1-3 Scars	16	72.7	72.7	95.5
4-6 Scars	1	4.5	4.5	100.0
Total	22	100.0	100.0	

platform surfaces are cortical. However, many had no visible facets, and it was impossible to determine if the surface was cortical or not. At least three specimens exhibited a non-cortical single facet platform surface. One of these specimens exhibits a ground platform surface (depth=4-7 feet) and one other has several flake scars (depth 7-12 feet) originating from the platform area.

Possible evidence for isolation of the platform area is provided in Table 34, recording the incidence of platform preparation scars. These data indicate that many specimens exhibit at least one previous flake scar on the dorsal proximal surface. By contrast, only five specimens reveal no potential platform preparation scars.

Specimens exhibiting a single or multiple flake scars originating from the platform surface are illustrated in Plate 12. These scars represent percussion damage to the platform area, in all probability occurring prior to flake detachment.

Dorsal Surface Characterticstics

Frequency data for dorsal surface attributes of percent cortex and number of dorsal surface scars are presented in Tables 35 and 36. A high proportion of indeterminate observations exists for both attributes. This fact is due to the difficulty in determining what constitutes a cortical surface for this raw material. In determining possible dorsal surface flake scars, it proved difficult to determine if dorsal surface ridges reflect the prior removal of

Plate 12. Platform preparation scars on ESP flakes.

Table 35

Percent Cortex

Category Label	Absolute Freq	Relative Freq (Pct)	Adjusted Freq (Pct)	Cum Freq (Pct)
Indeterminate	6	27.3	27.3	27.3
No Cortex	7	31.8	31.8	59.1
One Quarter or Less	2	9.1	9.1	68.2
To One Half	5	22.7	22.7	90.9
All Cortex	2	9.1	9.1	100.0
Total	22	100.0	100.0	

Table 36

Dorsal Scars

Category Label	Absolute Freq	Relative Freq (Pct)	Adjusted Freq (Pct)	Cum Freq (Pct)
Indeterminate	5	22.7	22.7	22.7
One Scar	5	22.7	22.7	45.5
Two Scars	9	40.9	40.9	86.4
Three Scars	2	9.1	9.1	95.5
Six Scars	1	4.5	4.5	100.0
Total	22	100.0	100.0	

percussion flakes or frost spalls. For these reasons, little confidence can be placed in these observations.

Flake Terminations

Frequency data for flake terminations is presented in Table 37. In this case indeterminate observations (22.7%) reflect either step terminations, or flakes that terminated off the core edge leaving a right angled distal end. Of the remaining specimens, the majority (54.5%) exhibit feather terminations, with the next largest category being hinge terminations (18.2%).

H. Discussion

Evaluation of these stone specimens is hindered by the small sample size, the great vertical separation of specimens, and the coarse-grained texture of the raw material, all of which makes it difficult to identify important attributes with confidence. However, the geomorphological context allows limited evaluation of the artificial or natural status of these specimens. The following discussion focuses on only the technical flake and flake fragments from the site, as the remainder of the collection consists of specimens exhibiting no evident human alteration (i.e., no evidence of percussion flake removal), or those in which the evidence is so minimal as to preclude meaningful evaluation.

Table 37

Flake Terminations

Category Label	Absolute Freq	Relative Freq (Pct)	Adjusted Freq (Pct)	Cum Freq (Pct)
Indeterminate	5	22.7	22.7	22.7
Feather	12	54.5	54.5	77.3
Step	1	4.5	4.5	81.8
Hinge	4	18.2	18.2	100.0
Total	22	100.0	100.0	

Arguments For a Human Origin

The strongest argument for a human origin for the specimens under consideration (flakes and flake fragments) lies in their objective status as technical flakes removed either by percussion blows or pressure. However, it has been demonstrated elsewhere that natural agencies of sufficient energy do exist which are capable of producing stone flakes exhibiting similar minimal morphological features (i.e., ribs, hackles, etc.) as are produced in human stoneworking. Using only this argument the question comes down to a probabalistic assessment as to whether or not a collection of this size could conceivably have been produced by natural forces alone, given the abundance of available flakeable materials and the potential energy indicated by the depositional agencies at the site.

A satisfactory answer to the first part of the question is unfortunately precluded by the excavation procedures employed prior to the 1979 field season when control samples of presumed naturally fractured specimens were not collected. The control data collected during the 1979 field season are useful but not directly applicable, as no flakes were recovered during those excavations. However, the control data are not completely reliable for other more serious reasons. In contrast to the geological situation described for the Timlin site, the lithology represented by the E.S.P. site materials has a definable outcrop location from which all materials must have been transported either by natural or cultural agencies. At the Timlin site, previous glacial transport served effectively to distribute the two lithologies across the landscape. Given the situation with a known local outcrop, materials transported to the site area would have undergone alteration and size reduction throughout their life history. On the other hand, small flakes may well have been created at some distance from their final resting place (assuming some limiting size range beyond which clasts are only slowly reduced). Given this situation it would be incorrect to compare the size of flakes with potential parental nodules in the form of natural clasts from the site deposits.

An assessment of the potential for natural processes, (as represented by the deposits at the site and elsewhere up the slope), to fracture chert conchoidally is an elusive problem. Clearly, the coarseness of the excavated deposits, including igneous boulders up to four feet in diameter, implies at least rare episodes in which energy was theoretically sufficient to remove stone flakes of the size represented in the collection. The periodicity of this energy level would, however, be a matter of pointless speculation.

As discussed earlier in this section, the majority of materials represented at the site probably reached their present position thru far less vigorous transport mechanisms; soil creep, runoff and rolling of larger clasts after they had been set in motion. These movements would have been of insufficient energy to produce even the medium-sized flakes represented in the E.S.P. collection. Their primary effect would have been of a much smaller scale including edge and ridge microflaking.

Thus the case for an artificial status of the flakes from this site is very weak when considering only their status as flakes in light of potential geomorphic forces. Given randomly occurring percussion blows of clast against clast during periods of mass movement (or at least movement of large masses) some 30-odd flakes scattered throughout a 3000 plus square foot area and representing over 25,000 years of time is not an unreasonable expectation.

The technological analysis discussed previously provides little data concerning flake attributes which would support an argument for an artificial status for the specimens. However, on the other hand, none of these specimens would seem anomalous within a primary archaeological context.

Attributes of gross shape indicate only that relatively little force would have been required for removal of these flake specimens. This observation fits well with an hypothesis of natural flaking, but is certainly also reconcilable with a human origin hypothesis.

Platform angles are generally within the range of values employed by hominid flintknappers. Although the values are all somewhat steep, this range could be expected in initial core preparation. The negative implication of the range of platform angle values is simply that bifacial thinning was not an activity represented by these specimens.

Proximal end attributes and dorsal surface characteristics provide only ambiguous information with which to evaluate this collection. Metric data platform width and depth indicate little in the way of platform isolation but with the point of force application located near the core edge. Possible platform preparation scars, while evident on several specimens, do not, in most instances follow a pattern consistent either with platform isolation or the removal of overhangs. Platform surface morphology reveals little evidence of modification prior to flake removal except in the case of several specimens exhibiting ground or faceted platforms. The data recorded for dorsal surface characteristics could potentially be used to argue for human alteration given the high incidence of one or more dorsal ridges. Although this conclusion may be correct, the nature of the physical weathering environment, especially as indicated by the numerous frost spalls, makes this conclusion extremely tenuous.

Arguments For a Natural Origin

Initially, it must be reiterated that the geomorphic situation at the E.S.P. site is theoretically competent to produce limited percussion flaking. Given this beginning premise, what evidence can be marshaled to support the position that natural events actually are responsible for the production of all flakes in this collection?

Both the size of the sample and the vertical distribution of specimens are in conformity with an hypothesis of natural flaking. Extrapolating the 22,000 BP date at 15 feet down to 27 feet would yield an average of one flake every 1500 years. However, the greatest frequency of flakes occurs in the upper eight feet of deposits representing perhaps as little as one thousand years.

The size of the flakes is also in conformity with a natural fracture model. Given the difficulty in removing large flakes in even a high energy environment when the respective particles are moving rapidly, small to medium-sized flakes, like those represented in the E.S.P. collection, would be an expected end-product. Angles of specimens are never less than 45 degrees which, if coupled with moderate length and a relatively thin cross-section, would constitute a flake of low probability under most natural conditions.

The possible platform preparation scars are not incompatible with flaking under natural conditions. If we assume that impact was randomly distributed around nodule surfaces, and of variable force amounts, then greater numbers of microflake scars should be removed from a given core face. In addition, those core faces more easily failed by virtue of their angle would presumably be more susceptible to both microflaking and the removal of large flakes. Thus whether or not a given flake exhibits pseudo-platform preparation scars would depend upon whether or not previous blows adjacent to the same core edge had occurred which were either of lesser force or located nearer the core edge. I have tried to argue that this occurrence would be of sufficient frequency in this context to result in a number of flakes bearing these features.

Further attributes such as percent cortex or dorsal scars are, for reasons discussed earlier, of questionable value in evaluating alternative models for the origin of these specimens.

In conclusion, none of the data recorded in this study would appear to contradict a natural origin for the flakes and flake fragments from this site. However, as indicated earlier, these specimens would not be out of place from an archaeological site in primary context.

I. Conclusion

The preceding analysis and discussion has demonstrated that the bulk of specimens making up the E.S.P. collection are either products of natural forces and processes or which they exhibit no alterations that would indicate that they had been altered by human activity. These specimens consist of thermal spalls and irregularly-shaped clasts exhibiting no evidence of conchoidal fracture. Clearly these specimens *could* have been utilized by humans though if they were they left no observable traces.

The remainder of the collection, consisting of technical flakes and flake fragments, is of more uncertain status. Given the size and dispersed nature of the collection it is impossible to reach any definite conclusions as to whether the specimens are naturefacts or artifacts. The specimens do conform to a natural fracture model if the geomorphic reconstruction outlined earlier has any validity. On the other hand, the flakes are not unlike those removed by hominids in the initial stages of core reduction.

Leaving aside the inconclusive question of whether the specimens are artifacts, a more attainable question can be posed. Does the collection of flaked chert excavated thus far justify the further expenditure of time and effort at this location? By way of a negative response to this rhetorical question I would put forward the following argument. From the preceding discussions I would argue that the case for a human origin for these specimens is very weak given their context. Further, if in fact these specimens are artifacts, (possibly the result of random rock smashing by hominids testing the quality of the local materials) there appears to be no incontrovertible way to demonstrate that fact even if half the mountain were excavated. On the other hand, these materials may be derived from a series of intact deposits farther upslope or be merely the remnants of at one time more extensive sites in the general vicinity of the present site. Given the general thinning of sediments upslope the former possibility is unlikely and would in any case be a hit or miss proposition. The latter possibility, though more probable leaves the same problem that if the remainder of the site has been largely removed and scattered there would be no means of demonstrating a hominid presence. In conclusion then, I would argue that this 'cryptic' redeposited site fails to meet any standards of verification and would probably continue to do so even in the event of future more extensive field work.

VII. Summary, Conclusions, and Suggestions for Future Research

A. Introduction

In preceding chapters the problem of evaluating natural versus human modifications of stone was examined. In Chapter II it was concluded that existing research tools for addressing this question were inadequate and in some cases inappropriate. Chapter III attempted to place natural fracture research on a firmer footing by emphasizing contextual analysis and the utility of performing analyses of manufacturing patterns. Finally, an attempt was made to evaluate the status of fractured stone specimens from three widely separated excavated sites representing different geomorphic contexts. The purpose of the present chapter will be to summarize and review the utility of the analytical methods outlined previously in terms of their utility in gaining a better understanding of fracture processes at these three sites. Suggestions for future experimental and empirical research are outlined in the final section.

B. Summary and Evaluation of Case Studies

Introduction

In chapters IV, V, and VI, three sites were examined in terms of their geomorphic context and alteration of stone specimens. At each site both the geomorphic situation and the nature of flakeable raw materials were quite different.

Comparisons and contrasts of these differences will be made in the present section.

Contextual Analysis

In Chapter III it was stressed that various geomorphic processes transport specimens in different manners due to variable energy levels and the nature of the transport medium. In addition, physical weathering environments may differ greatly between specimens deposited within a temperate floodplain environment and specimens deposited in high altitude colluvial sediments. The kinds of physical and chemical weathering processes in these environments can be expected to produce different weathering products.

At the Timlin site, reconstructable geomorphic environments included glacial and fluvial transport of natural clasts and fluvial transport of the artifactual specimens. At this site it was possible to distinguish specimens that had conclusively been transported by glacial ice (presence of striations). The absence of striations on the proposed artifact assemblage posed a strong argument against their fracture in a glacial environment and the existence of a collection of clasts that could be demonstrated to have been glacially fractured allowed the comparison of known naturally-fractured specimens with the proposed artifact collection. Using these lines of evidence it was possible to construct a strong case against the fracture of the Timlin collection by glacial action. In this case statistical comparisons of these two populations was appropriate.

At the Caribou Island site, known naturally-fractured specimens were available as well. In this instance specimens had been fractured in a manner and from directions uncharacteristic of human stoneworking techniques involving rounded quartzite cobbles. Some of the fracture patterns were shown to be the result of high energy pressure, which would not have been possible for people to produce. Other specimens, characterized by transverse splitting, could have been produced by human beings, (though they rarely employed this fracture strategy). Again, in this situation it was valid to perform comparative analyses between populations.

The E.S.P. site collection presented a more difficult analytical problem. Within this collection the vast majority of specimens were demonstrated to be the result of natural processes. Identifiable processes included freeze-thaw spalling, and other physical weathering phenomena. Because attributes on these natural specimens were not comparable to those on the technical flakes in the collection, it was not possible to perform meaningful comparative analyses of human versus natural flaking.

In the analysis of all three sites, the first step was to attempt to segregate specimens on the basis of observable attributes into populations of naturally-fractured specimens and those that may be either natural or human. If the fracture end-products are comparable then it is possible to undertake comparative statistical analyses between populations. If this cannot be carried out due to a lack of comparability then the initial segregation at least performs the function of reducing the number of specimens under observation and in clarifying the character of the fracturing environment for the general reader.

At most reported questionable sites in the New World (as well as in unquestionable sites), proposed human specimens generally occur with many other fractured clasts that are not felt to be artifacts. However, it is rare that the report cites criteria used for identifying naturally-fractured clasts. Without an initial attempt to identify a population of naturally-fractured clasts, comparative analyses, such as undertaken by Duvall and Veneer (1980), are inappropriate. More serious problems are encountered when, as in the study by Taylor and Payen (1979) naturally-fractured clasts are subjectively identified but are nevertheless included within the total population for analytical purposes.

When a contextually-oriented analysis is performed it may be possible to exclude with confidence one or more of the alternative fracture models from consideration, or at least to reduce the number of specimens from the field of observation. The Timlin site analysis demonstrated with a high probability that glacial transport was unlikely to have produced the proposed artifactual specimens from the site. Within the E.S.P. site collection, numbering several hundred specimens, all but about 30 could be safely excluded from further analysis because they were demonstrably natural in origin.

In other instances, the elimination of alternative hypotheses cannot be carried out with such a high degree of confidence. Within the analysis of the Timlin site collection, fracturing of chert clasts during fluvial transport could not be excluded with very high confidence. Rather, the combination of empirical lines of evidence (including flake scar widths), theoretical arguments regarding processes of fluvial transport and associated energy levels, as well as the technological arguments, made this alternative natural fracture hypothesis less acceptable than a human origin for the specimens.

In the analysis of the E.S.P. site collection the alternative arguments for either a human or natural origin for the flakes was even less conclusive. The lines of argument for a human origin were so weak in this case as to make the alternative natural fracture hypothesis the stronger of the two given the geomorphic context of the specimens.

Technological Analysis

As discussed in Chapter III, a technological analysis of flaked stone assemblages should form a basic component of any report on a particular site. At the very least such a study allows the reader to gain an appreciation of the range of materials collected from the site. However, for most sites containing questionable flaked stone materials it is doubtful whether a technological analyis will provide proof positive of a human origin for the specimens. Generally, assemblages of questionable specimens exhibit only minimal evidence of modification, hence their "questionable" status. On the other hand, when combined with contextual analyses, the technological approach may bring forward essential lines of argument which can be used to evaluate questionable assemblages.

In the evaluation of the Caribou Island site collection, the technological analysis provided strong evidence for non-acceptance of the bulk of fractured clasts from the lower gravels. In this instance, the argument against a human origin was not that human beings could not duplicate similar fracture by-products, but that human beings rarely, if ever, attempted to fracture rounded quartzite cobbles in this manner.

The technological analysis of the Timlin site was equally informative both in terms of supporting a human origin for the flakes and cores from the site as well as providing a possible explanation for the occurrence of the specimens in the stream gravels of the site. This analysis provided convincing proof that although glacially-flaked stone clasts and flakes occur in the stream gravels, the ranges of values for various flake attributes differ to such a degree that a glacial origin could be confidently rejected. In addition, a fluvial origin was assessed as being of low probability, given the ranges of values for attributes of flake size and manufacturing attributes.

On the other hand, the technological analysis of the E.S.P. site materials was essentially inconclusive with respect to the question of a human versus a natural origin. This analysis was hampered by the small sample size, the coarse lithology of the specimens, and the nature of the physical weathering environment.

C. Suggestions for Future Research

Empirical and Experimental Research

Empirical and experimental research into natural processes of rock fracture is a necessary pre-requisite to strengthening assessments of the status of questionable assemblages. Much useful research is already being conducted with respect to micromorphological alterations as exemplified by the work of Keeley (1980) and Stapert (1976a). These studies promise to place the evaluation of micromorphological alterations on fairly firm ground.

The same unfortunately cannot be said for pertinent research into natural micromorphological alterations. This lack of research relates to difficulties in obtaining funding, the goals of specific investigators, and the difficulties inherent in either observing of experimentally reproducing natural processes of the appropriate scale.

Regarding the first two points, the lack of funding and research interests of persons interested in the question of early man in the New World are interrelated. Firstly, the standards of verification of many scholars and funding administrators, preclude the consideration of redeposited sites as valid evidence (Griffin 1979). It is generally considered a higher priority to search for new sites rather than attempt to resolve the issues raised by excavated sites. Regarding the question of the natural versus human fracture of bone a similar situation does not exist. However, if it were not for the relevance of such studies to early man research in other areas, specifically Africa, it is doubtful that such research in the New World would be generously funded.

Secondly, scholars interested in the question of early man in the New World consistently fail to address the problem of natural fracture of stone. With notable exceptions (e.g., Reeves 1980, 1981), these archaeologists seem content to engage in a fruitless dialogue that can never be resolved without objective consideration of multiple hypotheses of stone alteration origin., Rather, these scholars jump from site to site revealing tantalizing clues seldom backed by carefully gathered evidence.

Regarding the third problem, it is true that natural processes are difficult to observe or replicate. However, limited study of particular environments are feasible as indicated by the Savage River study. In addition, it is not necessary to replicate or observe every conceivable natural process. As outlined in Chapter 3, if knowledge can be gained regarding the relevant parameters of specific environments, it should be possible to deduce expected alterations given a defined set of input conditions.

Technological Analyses

The most important realm of research to aid the technological analysis falls into two groups: those that aid in understanding the processes by which specific attributes are produced and, those that deal with inferences stemming from the combination of attributes on specimens.

Research into the first group has been underway since the early 1960's beginning with Crabtree's (1972) important study and later more quantified reserach (Bonnichsen 1977, Faulkner 1972, Speth 1972). This research is promising and has served as the basis for this thesis which, unfortunatley, was largely confined to attribute analyses.

Strengthened evaluation of technological analyses will only come about with means by which attributes can be evaluated in terms of their pattern on individual specimens. Pattern analysis may take the form of the reconstruction of production grammers of specimens and comparison of the grammer to known production grammers from experimental or prehistoric craftsmen. Young and Bonnichsen (n.d.a, n.d.b) are pioneering research into the technological grammer of experimental craftsmen. If reconstructed grammers from questionable specimens were found to "not make sense" in terms of an overall production strategy it may be possible to infer a natural origin (D.E. Young, personal communication 1982). The obvious drawback to application of these methods lies in the minimal alteration exhibited by specimens from most questionable assemblages.

D. Conclusion

The question of the antiquity of human beings in the New World is an important question for North American Archaeologists. Thus far the approaches taken to address this question have been largely unsystematic and undirected. This thesis has attempted to provide at least a general direction for research into one important area in the overall problem: that of recognizing alterations of stone produced by man from those produced by natural processes.

It has been argued throughout this thesis that archaeologists need to approach the question of a natural versus a human origin for questionable assemblages on an objective, quantified basis. Alternative hypotheses must be explicitly stated and tested. Important components to this assessment involve evaluation of the contextual parameters of specimens within a given geomorphic environment(s) and quantification of alterations of specimens. Unless similar studies are undertaken at other potentially important sites in North and South America, interested scholars will continue to be divided into separate and distinct, diametrically opposed camps. This unfortunatley is not science and does little to progress knowledge regarding the early occupants of the New World.

VIII. Bibliography

Adovasio, J.M., J.D. Gunn, J. Donahue, R. Stuckenrath, J. Guilday, and K. Lord

1977 Meadowcroft Rockshelter: a 16,000 year chronicle. In, Amerinds and their paleoenvironments in northeastern North America, edited by W.S. Newman and B. Salwen. *Transactions of the New York Academy of Sciences* 228: 137-160.

1978 Meadowcroft Rockshelter. In, Early Man in America From a Circum-Pacific Perspective, edited by A.L. Bryan, pp. 140-180. *Occasional Papers No. 1 of the Department of Anthropology, University of Alberta.* Archaeological Researches International, Edmonton.

Arai, F.

1971 Kita Kanto romu to sekki hogansotokuni zenki kyusekki bunkaso no shomondai. *Daiyonki Kenkyu* 10(4): 317-335.

Ascher, R., and M. Ascher

1965 Recognizing the emergence of man. *Science* 147(3655): 243-250.

Babcock, E.A., M.M. Fenton, and L.D. Andriashek

1978 Shear phenomena in ice-thrust gravels, central Alberta. *Canadian Journal of Earth Sciences* 15: 277-283.

Bada, J.L., and P.M. Helfman

1975 Amino acid racemization dating of fossil bones. *World Archaeology* 7(2): 160-173.

Baggerly, Carmen

1954 Waterworn and glaciated stone tools from the thumb District of Michigan. *American Antiquity* 20(2): 171-173.

1956 Artifacts of Lower Paleolithic and Eolithic pattern from drift of the Wisconsin glaciation, Cary substage in eastern Michigan. *New World Antiquity* 3: 3-7.

Barnes, A.S.
1939 The difference between natural and human flaking in prehistoric flint implements. *American Anthropologist* 41: 99-112.

Bartstra, K.M.
1978 The Patjitan culture: a preliminary report on new research. In, *The Early Paleolithic of South and East Asia*, edited by F. Ikawa-Smith, pp. 29-36. Mouton, The Hague.

Binford, L.
1981 *Bones: Ancient Men and Modern Myths.* Academic Press, New York. 320p.

Bleed, Peter
1977 Early flakes from Sozudai: Are they man-made? *Science* 197: 1357-1359.

Bonnichsen, R.
1968 Note II from the experimental laboratory: flake geometrics. *Archaeological Society of Alberta, Newsletter* 16: 4-12.

1977 Models for deriving cultural information from stone tools. *Mercury Series, Archaeological Survey of Canada, Paper* 60. National Museum of Man. Ottawa.

1978 Critical arguments for Pleistocene artifacts from the Old Crow Basin, Yukon: a preliminary statement. In, Early Man in America From a Circum-Pacific Perspective, edited by Alan L. Bryan, pp. 102-118. *Occasional Papers No. 1 of the Department of Anthropology, University of Alberta*. Edmonton.

1979 Pleistocene bone technology in the Beringian Refugium. *Mercury Series, Archaeological Survey of Canada Paper* 89. National Museum of Man. Ottawa.

Bonnichsen, R., and D. Young
1980 Early technological repertoires: stone to bone. *Canadian Journal of Anthropology* 1(1): 123-128.

n.d. Cognitive archaeology: systematics for flaked stone artifacts. Unpublished Manuscript.

Breuil, H.

1910 Sur la presence d'eolithes de la base de l'Eocene Parisien. *L'Anthropologie* 21: 395-408.

1932 Les industries a eclats du Paleolithic ancien: le Clactionian. *Prehistoire*, Pt. 1, fasc. 2, Paris.

1934 De l'importance de la solifluxion dans l'etude des terrains quaternaires du Nord de la France et des pays voisins. *Revue de Geographie Physique et de Geologie Dynamique* , 7(4): 269-331.

1943 On the presence of quartzites mechanically broken (sometimes simulating human workmanship) in the Dwyka Tillites and their derivation in the older gravels of the Vaal. *South African Journal of Science* XL: 285-286.

1945 Pseudo-implements from the glacial conglomerates at Nooitgedacht, Dist., Kimberley. *South African Journal of Science* XLI: 397-399.

Brink, J.W.

1978 An Experimental Study of Microwear Formation on Endscrapers. *Mercury Series, Archaeological Survey of Canada, Paper* 83. National Musuem of Man. Ottawa.

Bryan, A.L.

1965 Paleo-American Prehistory. *Idaho State University Museum, Occasional Papers* 16, Pocatello.

1978 An overview of Paleo-American prehistory from a circum-Pacific perspective. In, Early Man in America From a Circum-Pacific Perspective, edited by A.L. Bryan, pp. 306-327. *Occasional Papers No. 1, Department of Anthropology, University of Alberta.* Edmonton.

1981 The archaeological evidence for human adaptation to cold climates on the way to America. Proceedings of the Xth Congress, IUPPS(UICPP), Oct. 19-24, 1981. Miscelanea, pp. 44-62 (compilado y organizado por Joaquin Garcia-Barcena y Fernando Sanchez M.) Mexico.

n.d. The 1979 excavations and proposed future work at the Little Mt. Elden site. Unpublished Manuscript.

Bryan, A.L., and R. Bonnichsen
n.d. The Caribou Island site. Unpublished Manuscript.

Bryan, A.L., and R. Gruhn
1979 Results of a test excavation at Lapa Pequena, MG, Brazil. *Arquivos do Museu de Historia-UFMG III: 261-312.*

Butzer, K.
1976 *Geomorphology From the Earth*. Harper and Row, New York.

Cardich, A., L.A. Cardich, and A. Hajduk
1973 Sequencia arqueologica y cronologia radiocarbonica de la cueva 3 de los Toldos (Santa Cruz, Argentina). *Relaciones de la Sociedad Argentina de Antropologia* 7: 85-124.

Carter, George F.
1952 Interglacial artifacts from the San Diego area. *Southwestern Journal of Anthropology* 8(4): 444-456.

1956 Artifacts from the glacial gravels. *Ohio Archaeologist* 6: 82-84.

1957 *Pleistocene Man at San Diego*. Johns Hopkins Press, Baltimore.

1967 Artifacts and naturefacts: introduction. *Anthropological Journal of Canada* 5(1): 2-5.

1978 The American Paleolithic. In, Early Man in America From a Circum-Pacific Perspective, edited by A.L. Bryan pp. 10-19. *Occasional Papers No. 1 of the Department of Anthropology, University of Alberta*, Edmonton.

Chard, C.S.
1959 New World origins: A reappraisal. *Antiquity* 33: 44-49.

Childers, W.M.
1977 Ridge-back tools of the Colorado Desert. *American Antiquity* 42(2): 242-248.

Childers, W.M., and H.L. Minshall
1980 Evidence of Early Man exposed at Yuha Pinto Wash. *American Antiquity* 45(2): 297-307.

Clark, J.D.
1958 The natural fracture of pebbles from the Batoka Gorge, Northern Rhodesia, and its bearing on the Kafuan industries of Africa. *Prehistoric Society Proceedings* 34: 64-77.

Cole, J.R., and L.R. Godfrey
1977 On "Some Paleolithic tools from northeast North America." *Current Anthropology* 18(3): 541-543.

Cotterell, B., and J. Kamminga
1979 The mechanics of flaking. In, *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 97-112. Academic Press, Inc, New York.

Crabtree, D.E.
1972 An Introduction to Flintworking. *Occasional Papers of the Idaho State University Museum*, No. 28, Pocatello.

Derevianko, A.P.
1978 The problem of the Lower Paleolithic in the south of the Soviet Far East. In, *Early Paleolithic in South and East Asia*, edited by F. Ikawa-Smith, pp. 303-315. Mouton, The Hague.

Drake, L.D.
1972 Mechanisms of clast attrition in basal till. *Geological Society of America Bulletin*, 83: 2159-2166.

Drew, D.L.
1979 Early Man in North America and where to look for him: geomorphic contexts. *Plains Anthropologist* 24(86): 269-281.

Duvall, J., and W. Veneer
1980 Statistical analysis of lithics from the Calico site. *Journal of Field Archaeology* 6: 455-462.

Faulkner, A.
1972 Mechanical Principles of Flintworking. Ph.D Dissertation, Dept. of Anthropology, Washington State University, Pullman.

Fleisher, P.J.
1980 Geology of the Timlin site, Hyndesville, New York. Unpublished Manuscript.

Flenniken, J.J., and J.C. Haggarty
1980 Trampling as an agency in the formation of edge damage: an experiment in lithic technology. *Lithic Technology* 9: 208-214.

Funk, R.E.
1977 On "Some Paleolithic tools from northeast North America". *Current Anthropology* 18(3): 543-544.

Goodman, J.
1977 *Psychic Archaeology: Time Machine to the Past.* Berkeley Putnam, New York.

n.d. The ESP site: man in the New World more than 100,000 years ago (a preliminary report). Unpublished Manuscript.

Griffen, J.B.
1979 The origin and dispersion of American Indians in North America. In, *The First Americans: Origins and Adaptations*, edited by W.S. Laughlin and A.B. Harper, pp. 43-55. Gustav Fischer, New York.

Gruhn, R.
1978 A note on excavations at El Bosque, Nicaragua in 1975. In, Early Man in America From A Circum-Pacific Perspective, edited by A.L. Bryan, pp. 261-262 . *Occasional Papers No. 1 of the Department of Anthropology, University of Alberta.* Edmonton.

Gruhn, R., and D.E. Young

1980 The burial of Calico is premature: a critique of Duvall and Veneer. *Journal of Field Archaeology* 7: 499-500.

Hallam, S.J.

1977 The relevance of Old World archaeology to the first entry of man into New Worlds: colonization seen from the Antipodes. *Quaternary Research* 8: 128-148.

Haynes, C.V., Jr.

1967 Carbon-14 dates and Early Man in the New World. In, *Pleistocene Extinctions: The Search for a Cause*, edited by P.S. Martin and H.E. Wright, pp. 267-286. Yale University Press, New Haven.

1969 The earliest Americans. Science 166: 709-715.

1973 The Calico site: artifacts or geofacts? *Science* 181: 305-310.

1974 Paleoenvironments and cultural diversity in late Pleistocene South America: a reply to A.L. Bryan. *Quaternary Research* 4: 378-382.

1980 The Clovis culture. *Canadian Journal of Anthropology* 1(1): 115-121.

Holmes, C.D.S.

1960 Evolution of till stone shapes, central New York. *Geological Society of America, Bulletin* 71, pp. 1645-1660.

Holmes, W.H.

1893 Gravel man and Paleolithic culture: A preliminary view. *Science* 21, pp. 29-30.

1919 Handbook of aboriginal American antiquities: Part I. The lithic industries. *Bureau of American Ethnology, Bulletin* 60.

Honea, K.M.

1965 A morphology of scrapers and their production. *Southwestern Lore* 31(2).

Howchin, W.
1921 On the occurrence of aboriginal stone implements of unusual type in the table-lands regions of Central Australia. *Transactions and Proceedings of the Royal Society of South Australia* XIV: 206-230.

Hurt, W.R., T. van der Hammen, and G. Correal Urregro
1976 *The El Abra Rockshelters, Sabana de Bogota, Colombia*. Indiana University Museum, Occasional Papers and Monographs 2. Bloomington.

Ikawa-Smith, F.
1978a The history of Early Paleolithic research in Japan. In, *The Early Paleolithic in South and East Asia* edited by F. Ikawa-Smith, pp. 247-286.

1978b Lithic assemblages from the Early and Middle Upper Pleistocene formations in Japan. In, Early Man in America From a Circum-Pacific Perspective, edited by Alan L. Bryan, pp. 42-53. *Occasional Papers No. 1 of the Department of Anthropology, University of Alberta*. Edmonton.

Irving, W.N.
1971 Recent Early Man research in the North. *Arctic Anthropology* 8: 68-82.

Irwin, H.T.
1971 Developments in early man studies in western North America. *Arctic Anthropology* 8(2): 42-64.

Isaac, G.L.
1967 Towards the interpretation of occupation debris-some experiments and observations. *Kroeber Anthropological Society Paper* 5(37): 31-57.

1977 *Olorgesaile*. University of Chicago Press, Chicago.

Johnson, F., and J.P. Miller
1958 Review of G.F. Carter, Pleistocene Man at San Diego. *American Antiquity* 24: 206-210.

Johnson, L. Lewis
1978 A history of Flint-knapping experimentation, 1838-1976. *Current Anthropology* 19(2): 337-372.

Jones, F.W., and T.D. Campbell
1925 A contribution to the study of eoliths: Some observations on the natural forces at work in the production of flaked stones on the central Australian Tablelands. *Journal of the Royal Anthropological Institute* 55: 115-122.

Judson, S., and R.E. Barks
1961 Microstriations on polished pebbles. *American Journal of Science* 259: 371-381.

Keeley, L.H.
1974 Technique and methodology in microwear studies: a critical review. *World Archaeology* 5: 323-336.

1980 *The Experimental Determination of Stone Tool Uses.* University of Chicago Press, Chicago.

Keeley, L.H., and M.H. Newcomer
1977 Microwear analysis of experimental flint tools: a test case. *Journal of Archaeological Science* 4: 29-62.

Klein, R.G.
1971 The Pleistocene prehistory of Siberia. *Quaternary Research* 1(2): 133-161.

1975 The relevance of Old World archaeology to the entry of man into the New World. *Quaternary Research* 5(3): 391-394.

Krieger, A.D.
1958 Review of George F. Carter, Pleistocene Man at San Diego. *American Anthropologist* 60: 974-978.

1964 Early Man in the New World. In, *Prehistoric Man in the New World*, edited by J.D. Jennings and E. Norbeck, pp. 23-84. University of Chicago Press, Chicago.

Krumbein, W.C.
1941a The effects of abrasion on the size, shape, and roundness of rock fragments. *Journal of Geology* 49: 482-520.

1941b Measurments and geological significance of shape and roundness *Journal of Sedimentary Petrology* 11: 64-72.

Kuenan, Ph.H.
1956 Experimental abrasion of pebbles, 2. Rolling by current. *Journal of Geology* 64: 336-368.

1964 Experimental abrasion 6. Surf action. *Sedimentology* 3: 2943.

Kuenan, Ph.H., and W.G. Perdok
1962 Experimental abrasion 5. Frosting and defrosting of quartz grains. *Journal of Geology* 38: 437-446.

Kupsch, W.O.
1965 Jointing of boulders caused by flowing ice. Alberta Society of Petroleum Geologists, 15th Annual Field Conference Guidebook, Part 1, Cypress Hills Plateau: 112-115.

Laville, H., J-P. Rigaud, and J. Sackett
1980 *Rock Shelters of the Perigord: Geological Stratigraphy and Archaeological Succession.* Academic Press, Inc., New York.

Leakey, L.S.B., R.D. Simpson, and T. Clements
1968 Archaeological excavations in the Calico Mountains, California: Preliminary report. *Science* 160: 1022-1023.

Leopold, L.B., W.W. Emmett, and R.M. Myrick
1966 Channel and hillslope processes in a semi-arid area. *New Mexico Geological Survey Professional Papers* 352-G.

Lynch, T.F.
1974 The antiquity of man in South America. *Quaternary Research* 4: 356-372.

1978 The South American paleo-indians. In, *Ancient Native Americans*, edited by J.D. Jennings, pp. 455-489. W.H. Freeman and Co., San Francisco.

MacCurdy, G.G.
1905 The Eolithic problem: Evidence of a rude industry antedating the Paleolithic. *American Anthropologist* 71: 425-479.

MacNeish, R.S.
1976 Early man in the New World. *American Scientist* 64: 316-327.

Martin, P.S.
1967 Prehistoric overkill. In, *Pleistocene Extinctions*, edited by P.S. Martin and H.E. Wright, pp. 75-120. Yale University Press, New Haven.

1973 The discovery of America. *Science* 179(4077): 969-974.

McPherson, H.C.
1971 Downstream changes in sediment character in a high energy mountain stream. *Arctic and Alpine Research* 3: 65-79.

Minshall, H.L.
1973 Bipolar flaking in quartzite at Buchanan Canyon. *Anthropological Journal of Canada* 11(1): 20-24.

Moir, R.
1912 The making of a Rostro-carinate implement. *Nature* 90(2247): 334.

1919 *Pre-Paleolithic Man*. London.

1921 The natural fracture of flint and its bearing upon rudimentary flint implements. *Proceeding, Prehistoric Society, East Anglia* 1: 171-184.

Morlan, V.J.
1971 The pre-ceramic period of Japan: Honshu, Shikoku, and Kyushu. *Arctic Anthropology* 8: 136-170.

Morlan, R.E.
1981 Big bones and tiny stones: early evidence from the northern Yukon Territory. Proceedings of the Xth Congreso, IUPPS(UICPP), Oct. 19-24, 1981. Comision

XII, El Poblimiento de America. Coloquio: Evidencia arqueologica de occupacion humana en America anterior a 11,500 anos a.p., pp. 1-26 (compilado y organizado por Alan Bryan), Mexico.

1981 Evidence for pre-Clovis human occupations north of the ice-sheets in North America. Paper presented at the 46th annual meeting of the Society for American Archaeology, San Diego.

Mossiman, J.E., and P.S. Martin
1975 Simulating overkill by Paleo-Indians. *American Scientist* 63(3): 304-313.

Nie, N.H., C.H. Hull, J.G. Jenkins, and K. Steinbrenner
1975 *Statistical Package for the Social Sciences.* (second edition). McGraw-Hill, Inc., New York.

Oakley, K.P.
1972 *Man the Toolmaker*. Sixth edition, University of Chicago Press, Chicago. 101p.

Odell, G.H.
1980 Butchering with stone tools: some experimental results. *Lithic Technology* 9(2): 39-47.

Odell, G.H., and F. Odell-Vereecken
1980 Verifying the reliability of lithic use-wear determinates by "blind tests": the low power approach. *Journal of Field Archaeology* 7: 87-120.

Ohel, M.Y.
1978 Conditions for establishing deliberate modifications of lithic specimens. Paper presented at the 43d annual meeting of the Society for American Archaeology, Tucson.

1979 The Clactonian: an independent complex or an integral part of the Acheulean? *Current Anthropology* 20(4): 685-726.

Ohyi, H.
1978 Comments on the Early Paleolithic of Japan. In, *Early Paleolithic of South and East Asia*, edited by F. Ikawa-Smith, pp. 299-301. Mouton, The Hague.

Page, W.
1978 The geology of the El Bosque archaeological site. In, Early Man in America From a Circum-Pacific Perspective, edited by A.L. Bryan, pp. 231-260. *Occasional Papers No. 1 of the Department of Anthropology, University of Alberta*, Edmonton.

Patterson, L.
1977 Comments on Texas Street lithic artifacts. *Anthropological Journal of Canada* 15(4): 15-25.

1980 Comments on a statistical analysis of lithics from Calico. *Journal of Field Archaeology* 7: 374-377.

n.d. Criteria for man-made lithic attributes. Paper submitted to American Archaeologist.

Pei, Wen Chung
1936 Le role des phenomenes naturels dans l'eclatement et le faconnement des roches dures utilisees par l'homme prehistorique. *Revue de Geographie Physique et de Geologie Dynamique* 9: 349-423.

Pettijohn, F.J.
1975 *Sedimentary Rocks*. Harper and Row, N.Y. 628 p.

Phagen, C.J.
1976 A method for the analysis of flakes in archaeological assemblages: A Peruvian example. Unpublished Ph.D. dissertation, Department of Anthropology, Ohio State University, Columbus.

Pittman, E.D., and T. Ovenshine
1968 Pebble morphology in the Merced River (California). *Sedimentary Geology* 2: 125-140.

Powers, W.R.
1973 Paleolithic man in northeast Asia. *Arctic Anthropology* 10(2): 1-106.

Raemsch, B.E.
1976 Some early man cultures of the Catskill region. In, *Archaeology and Geochronology of the Susquehanna and Schoharie Regions*, edited by J.R. Cole and L.R. Godfrey, pp. 17-24. Proceedings of the Yager Conference at Hartwick College.

1977 Some Paleolithic tools from northeast North America. *Current Anthropology* 18(1): 97-99.

1978 On criticisms of "Some paleolithic tools from northeast North America". *Current Anthropology* 19(1): 157-158. Raemsch, B.E., and W.W. Vernon

Reeves, B.O.K.
1980 Fractured cherts from Pleistocene fossiliferous beds at Medicine Hat, Alberta. In, *Early Native Americans*, edited by D.L. Browman, pp. 38-98. Mouton, The Hague.

Renaud, E.B.
1936 The Archaeological Survey of the High Western Plains, Seventh Report. Southern Wyoming and Southwest South Dakota. Department of Anthropology, University of Denver.

1938 The Black's Fork Culture of Southwest Wyoming. The Archaeological Survey of the High Western Plains. Department of Anthropology, University of Denver.

1940 The Archaeological Survey of the High Western Plains Seventh Report. Department of Anthropology, University of Denver.

1943 Archaeological Survey of Western Nebraska. Department of Anthropology, University of Denver: 12-20.

Reynolds, P.D.
1971 *A Primer in Theory Construction*. Bobbs-Merrill, Indianapolis.

Rinehart, J.S.
1966 Fracture of rocks. *International Journal of Fracture Mechanics* 2: 534-551.

Ritchie, W.A., and R.E. Funk
1969 Comments on "Archaeology studies in central New York." *New York Glaciogram* 4(1): 13-16.

Roosa, W.B., and S.L. Peckham
1954 "Notes on the third interglacial artifacts." *American Antiquity* 19(3): 280-281.

Rottlander, R.
1975 The formation of patina of flint. *Archaeometry* 17: 106-110.

Rouse, I.
1976 Peopling of the Americas. *Quaternary Research* 6(4): 567-612.

Rutot, A.
1902 Les actions naturelles possibles sont inaptes a produire des effets semblables a la retouche intentionelle. *Bulletin et Memoires de la Societe d'Anthropologie de Bruxelles* 23(1): 1-22.

Schiffer, M.B.
1976 *Behavioral Archaeology*. Academic Press, Inc., New York.

Schuiling, W.C.
1972 *Pleistocene Man at Calico*. San Bernardino County Museum Association, Bloomington.

Schumm, S.A., and M.A. Stevens
1973 Abrasion in place: a mechanism for rounding and size reduction of coarse sediments in rivers. *Geology* 1: 37-40.

Schwartz, A.
1914 Some suggestions for organized research on flint implements. *Proceedings, Prehistoric Society of East Anglia* 1: 449-454.

Sellards
1952 *Early Man in America: a Study in Prehistory*. University of Texas Press, Austin.

Semenov, S.A.
1964 *Prehistoric Technology*. Cory, Adams and Mackay,

London.

Serizawa, C.
1978 The Early Paleolithic in Japan. In, *The Early Paleolithic of South and East Asia*, edited by F. Ikawa-Smith, pp. 287-297. Mouton, The Hague.

Shackley, M.L.
1974 Stream abrasion of flint implements. *Nature* 248(5448): 501-502.

1978 The behavior of artefacts as sedimentary particles in a fluviatile environment. *Archaeometry* 20(1): 55-61.

Sharrock, F.W.
1966 Prehistoric Occupation Patterns in Southwestern Wyoming and Cultural Relationships with the Great Basin and Plains Culture Areas. *Anthropological Papers of the University of Utah*, No. 77.

Simpson, R.D., L.W. Patterson, and C.A. Singer
1981 Early lithic technology at the Calico site, southern California. Paper presented at the International Union of the Prehistoric and Protohistoric Sciences, Mexico City.

Sneed, E.D., and R.L. Folk
1958 Pebbles in the lower Colorado River--a study in particle morphogenesis. *Journal of Geology* 66: 114-150.

Speth, John
1972 Mechanical basis of percussion flaking. *American Antiquity* 37: 34-60.

Stagg, R.M., W.W. Vernon, and B.E. Raemsch
1980 Wisconsin and pre-Wisconsin stone industries of New York and related tools from a shop site near Tula, Mexico. In, *Early Native Americans*, edited by D.L. Browman, pp. 41-68. Mouton, The Hague.

Stapert, D.
1976a Some natural surface modifications on flint in the Netherlands. *Paleohistoria* XVIII(7): 7-41.

1976b Middle paleolithic finds from the northern Netherlands. *Paleohistoria* 18: 42-58.

Starna, W.A.
1977 On "Some Paleolithic tools from northeast North America". *Current Anthropology* 18(3): 545.

Stirrup, M.
1885 On the so-called worked flints from the Miocene beds of Thenay, in France. *Journal of the Royal Anthropological Institute* 14: 289-290.

Taylor, R.E., and L.A. Payen
1979 The role of archaeometry in American archaeology: Approaches to the evaluation of the antiquity of *Homo sapiens* in California. In, *Advances in Archaeological Method and Theory Vol. 2*, edited by M.B. Schiffer, pp. 239-277. Academic Press, Inc, New York.

Thomas, D.H.
1976 *Figuring Anthropology: First Principles of Probability and Statistics*. Holt, Rinehart, and Winston, New York.

Tringham, R., G. Cooper, G. Odell, B. Voytek
1962 Experimentation in the formation of edge damage: a new approach to lithic analysis. *Journal of Field Archaeology* 1: 171-195.

Tsirk, A.
1979 Regarding fracture initiations. In, *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 83-96. Academic Press, Inc, New York.

Vernon, W.W.
1976 Geology and geochronology of the Timlin site. In, *Archaeology and Geochronology of the Susquehanna and Schoharie Regions*, edited by J.R. Cole and L.R. Godfrey, pp. 17-24. Proceedings of the Yager Conference at Hartwick College. Oneonta.

Warren, S.H.
1905 On the origin of eolithic flints by natural causes, especially by the foundering of drifts. *Journal of the Royal Anthropological Institute* 35: 337-364.

1914 The experimental investigation of flint fracture and its application to problems of human implements. *Journal of the Royal Anthropological Institute* 44: 425.

1921 A natural "eolith" factory beneath the Thanet Sand. *Quarterly Journal of the Geological Society, London* 76: 238-253.

1923 Sub-soil flint flaking sites at Grays. *Proceedings, Geologists Association* 34: 38.

Wentworth, C.K.
1919 A laboratory and field study of cobble abrasion. *Journal of Geology* 27: 507-521.

1922 A field study of the shapes of river pebbles. *United States Geological Survey Bulletin* 730: 103-114.

1931 Pebble wear on Jarvis Island Beach.

White, S.E.
1976 Is frost action really only hydration shattering? A review. *Arctic and Alpine Research* 8(1): 1-6.

Wilmsen, E.N.
1970 Lithic Analysis and Cultural Inference: A Paleo-Indian Case. *Anthropological Papers of the University of Arizona* No. 16.

Workman, W.B.
1980 Holocene peopling of the New World: implications of the arctic and subarctic data. *Canadian Journal of Anthropology* 1(1): 129-139.

IX. Appendix I

A. The Savage River Experiment

In preceding sections, a certain dissatisfaction was expressed concerning the design of experiments to evaluate the kind and rate of attrition in a fluvial environment. The presence or absence of water, while necesary, is not a sufficient condition to simulate particle movement in an aqueous regime (e.g., Tringham et al. 1974). For these reasons it was decided to conduct an experiment in a controlled situation of horizontally flowing water.

For these purposes, two situations are suitable for examining abrasion in a fluvial environment; flumes, and natural streams. The advantages of the former are many in that is is possible to control precisely a host of input variables (rate of flow, time, matrix); however, several disadvantages make natural environmenents more suitable.

The greatest disadvantages in using flume apparatuses are limits on the size of clasts that can be introduced and on the size of the bed load medium. In addition, comparisons of the rate of attrition in natural streams and laboratory conditions indicate that laboratory abrasion proceeds somewhat slower for a given distance traveled.

The size limitations inherent in flume experiments allow for the study of micromorphological alterations but make it nearly impossible to study macromorphological alterations. For these reasons, it was decided to utilize a natural stream environment.

Comparability

One final issue in designing experiments to observe alterations to clasts in fluvial environments must be discussed; the issue of comparability. Streams differ greatly along continua of several crucial variables (e.g., bed load, velocity) that make it difficult to interpret specimens from archaeological sites directly from the experimentally derived results. Thus, the lack of production of large flake removals in an experimental situation cannot then be used to infer that no large flakes were removed in the archaeological situation. Thus, only general principles applicable to all situations may be applied, and not context specific processes.

Location

The Savage River in western Maryland periodically is allowed to flow past a dam from a reservoir during high water levels. After issuing out of the drainage pipe, the waters flow rapidly down a steep gradient for about four miles to the west branch of the Potomac river. Along its short bed the stream encounters a number of man-made and bedrock-controlled topographic features which provide a certain amount of variability in the rate and kind of flow in the stream. For much of its course the stream consists of a boulder-strewn channel that at peak flow produces large waves and "holes." Other portions of the channel consist of deep pools with a relatively slower rate of flow. For this experiment, an area largely free of boulders with imbricated cobble-sized clasts lining the channel floor was selected. This particular area was chosen because of nearness to the road and accessibility of specimens after subsidence of the stream. The lack of boulders and deep channels allowed for a very high rate of recovery of specimens.

Experimental Specimens

A total of 330 chert and siliceous siltstone specimens were placed in the stream during low water. The lithology of these specimens differed in no significnt way from the lithologies represented in the Timlin collection. In fact, the majority of flakeable specimens were siliceous siltstone and chert clasts collected from fluvial gravels at the West Branch.

As stated earlier, the purposes of this experiment were to test both macro- and micromorphological alterations in a fluvial context. For these reasons it was decided to utilize a wide range of sizes and morphologies of clasts. The majority of specimens consisted of medium to large flakes, with smaller numbers of small flakes and large nodules. For the large nodules, both rounded and freshly fractured specimens were utilized.

Specimens were subjected to high water levels for approximately 20 hours; 10 hours per day. Specimens were placed along two lines perpendicular to the flow of the stream and separated by about 30 feet. In addition, in the face of the rapidly impending approach of the flood waters, a number of flakes were hurriedley placed in a tight circular cluster in a position further upstream. The latter specimens were approximately 30 feet upstream from a boulder-strewn rapids at the head of which the downstream lines of clasts were placed.

Movement of Clasts

From the relatively high velocity of the river at flood stage and the occasional large size of clasts within the bedload that had apparently been moved to their present position by the stream, it was expected that considerable movement of clasts, particularly the smaller ones, would take place over a two-day period. However, very little actual movement took place, and what movement did occur was in the largest and smallest size range. The very largest specimen, weighing approximately kg, moved about 36 feet; and one small flake placed in a trough at the head of the rapids was transported almost 60 feet. The great majority of specimens were not transported much over 3 feet, with many experiencing no movement at all. The explanation for this pattern of movement is, with hindsight, in perfect conformity with general principles of fluid dynamics and processes of particle movement in fluviatile environments. Some of the variables involved in whether or not specific clasts will move or not are stochastic while others can be largely controlled.

Damage to Specimens

For very practical reasons, only those specimens which exhibited observable damage were recovered from the stream; approximately 149 specimens were left for recovery at a future date after further periods of transport. Thus only 45.1% of the specimens introduced into the stream underwent macroscopic alterations, though the remainder may well have undergone microscopic damage. The majority of the damage to specimens consisted of the removal of paint, and, presumably, portions of ridges and edges. In most cases this wear undoubtedly resulted from abrasion by sand-sized particles in suspension. Other specimens which traveled an appreciable distance exhibit evidence of more extreme edge and ridge wear due to sliding and rolling over immobile clasts.

In addition to edge and ridge abrasive wear, a number of specimens exhibit percussion craters on ridges, as described by Shackley (1974), although on a much larger scale due to the greater size of particles in this experiment. These percussion craters are also visible, to a lesser extent, on one or more faces of several specimens.

Damage to flake and nodule edges represents the most extensive modification of specimens. On virtually all flake-specimens, paint was removed from edges by the detachment of small (up to several mm in length) microflakes. On several specimens, relatively large .1 to 1cm flakes were detached. Flakes larger than one cm were primarily restricted to nodules or very large flakes.

Macromorphological Alterations

Table 38 presents metric data for the dimensions of flakes removed during the experiment. Of these flake removals, only eleven exceeded one cm in length, the majority of these being between one and two cm (nine specimens). Only one flake removal (3.7 cm long x 5.2 cm wide) approaches the size of specimens in the Timlin collection.

Due to the small size of the majority of flake removals, the Beta angle measurement is meaningless. For scars of this size, the Beta angle relates more realistically to the availability of edges possessing angles of varying degrees. In this instance, the majority of edges of flakes are acute.

For flakes exceeding 1 cm in length, six flakes possess feather terminations, with four step and one hinge termination. Although too small a sample to generalize from, these data conform to Model 4 predictions outlined in Chapter III.

Micromorphological Alterations

The most prevalent kind of alteration suffered by specimens consisted of small, edge-microflaking. All recovered specimens exhibited greater or lesser degrees of this form of damage. The majority of microflakes were under 1 mm in length and visible only with the aid of a binocular microscope.

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Table 38

Metric Data Savage River Flake Scars

	Mean	Std. Error	Std. Dev.	Variance	Kurtosis	Skewness	Range	Minimum	Maximum	# of Specimens
Length	0.48	0.06	0.58	0.34	13.64	3.32	3.70	0.10	3.70	98
Width	0.63	0.67	0.66	0.43	24.62	4.14	5.20	0.10	5.20	98
Angle	74.51	1.86	18.10	327.48	0.62	0.60	87.00	40.00	127.00	94
Length x Width	0.58	0.18	1.80	3.24	66.66	7.64	16.64	0.10	16.64	98
Length/Width	0.74	0.05	0.45	0.20	10.40	2.65	3.00	0.10	3.00	98

Although only in the incipient stages, the effect of this edge microflaking would probably be to dull or round the edges of flakes and nodules and, to a lesser extent, ridges. A similar phenomenon was reported by Kuenan (1956: 352) for angular pebbles rolled in a circular flume.

Flake scar termination observations of these microflakes were recorded for flakes between one and ten mm in length (Table 39). Again, the majority of flake scars exhibit feather terminations (54%) though a significant percentage (44%) exhibit right-angled terminations (hinge and step). In addition, the majority of flake scars exhibit cone features in contrast to bending fracture features.

Table 39

Flake Scar Terminations

	Absolute Freq	Relative Freq (Pct)	Cum Freq (Pct)
Indeterminate	2	2.0	2.0
Hinge	16	16.3	18.4
Step	27	27.6	45.9
Feather	58	54.1	100.0
Total	98	100.0	100.0